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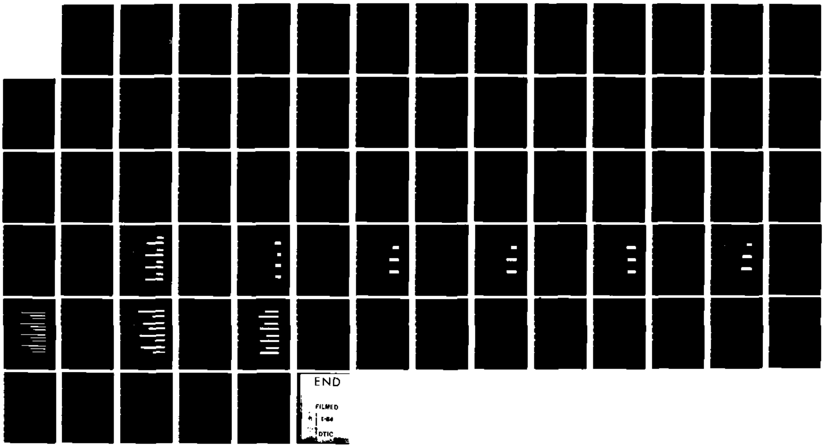

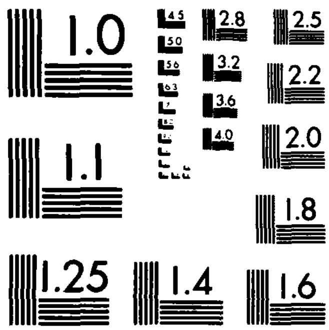

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A LONG TERM ASSESSMENT OF THE CLINICAL EFFICACY
OF THE FIBEROTOMY AS IT RELATES
TO ROTATIONAL RELAPSE

by

WALTER D. RYE

A thesis submitted in partial fulfillment
of the requirements for the degree of

Master of Science in Dentistry

University of Washington

1983

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Program Authorized
to Offer Degree Orthodontics

Date October 13, 1983

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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER AFIT/CI/NR 83-75T	2. GOVT ACCESSION NO. AD A135 837	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) A Long Term Assessment of the Clinical Efficacy of the Fiberotomy as it Relates to Rotational Relapse		5. TYPE OF REPORT & PERIOD COVERED THESIS/DISSERTATION
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Walter D. Rye		8. CONTRACT OR GRANT NUMBER(s) -
9. PERFORMING ORGANIZATION NAME AND ADDRESS AFIT STUDENT AT: University of Washington Seattle		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS AFIT/NR WPAFB OH 45433		12. REPORT DATE 1983
		13. NUMBER OF PAGES 56
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)		15. SECURITY CLASS. (of this report) UNCLASS
		15a. DECLASSIFICATION DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

APPROVED FOR PUBLIC RELEASE; DISTRIBUTION UNLIMITED

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

APPROVED FOR PUBLIC RELEASE: IAW AFR 190-17

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Abstract

A LONG TERM ASSESSMENT OF THE CLINICAL EFFICACY
OF THE FIBEROTOMY AS IT RELATES TO ROTATIONAL RELAPSE

Walter D. Rye, D.D.S.
Captain, USAF
pp. 56
Master of Science in Dentistry
University of Washington, Seattle, WA
1983

This study was undertaken to assess the clinical efficacy of the fiberotomy as it relates to long term rotational stability of dentition.

Forty-eight orthodontic patients who had received conventional edgewise orthodontic treatment provided control and experimental samples consisting of 91 non-fiberotomized, orthodontically rotated teeth and 73 fiberotomized, orthodontically rotated teeth. All teeth had been retained for a minimum period of six months following treatment.

After a minimum postretention period of two years, assessment of rotational stability was conducted using photocopies of dental casts made at three time periods: pretreatment, posttreatment, and post-retention.

Mean stability, a measure of percentage of treatment rotation maintained at the postretention period, was found to be 77.2 percent for the fiberotomized sample compared to 61.0 percent for the non-fiberotomized sample. The difference in stability was statistically significant with the probability that this difference could have occurred due to chance of less than one percent.

Conclusions derived from this study included: 1) fiberotomy will reduce the potential for rotational relapse probably by inactivating forces developed within displaced gingival fibers; 2) there does not appear to be a difference in relapse potential between arches or tooth categories; and 3) there does not appear to be a relationship between amount of treatment rotation and percent relapse.

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Date 13 October 1983

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ACKNOWLEDGMENTS

The author would like to offer gratitude to those individuals who participated in the construction of this thesis: Dr. Robert Little, Dr. Richard Riedel, Dr. Don Joondeph, Dr. Peter Shapiro, and Dr. Vince Kokich. Consideration is also deserved by Mike Chapko for his invaluable aid in evaluating the statistical significance of the data derived from this study. I would also like to thank my wife and family for their patient indulgence. This study was funded in part by the University of Washington Orthodontic Memorial Fund.

INTRODUCTION

Over the years, remarkable advances have been made in the mechanical aspects of orthodontic therapy. Preformed bands, bondable brackets, flexible archwires, and orthognathic surgery are but a few of the recent advances unavailable to the early practitioners of orthodontics. Although our ability to correct malocclusions has been vastly simplified, our ability to retain these corrected dentitions is still very limited.

The problem of retention has perplexed orthodontists almost as long as orthodontics has existed as a profession. Case (1920) stated, "If there is one part of orthodontia more than another that is absolutely indispensable to the success of this specialty and its establishment upon a firm foundation as one of the arts and sciences, it is the permanent retention of regulated teeth." Oppenheim (1934) was more succinct when he claimed, "Retention is the most difficult problem in orthodontia, in fact it is <u>the</u> problem." These same sentiments are expressed today by conscientious practitioners who possess enough courage to examine their postretention cases.

Innumerable retention philosophies have been advanced over the years. Riedel (1960), having reviewed the retention problem, enumerated some of the factors and principles thought to be important by various individuals. These included: slight movement is more difficult to retain than extensive movement; elastics should be worn continuously as a part of retention; retention should depend on a fixed type of appliance; satisfactory retention is dependent upon modification of structure and function of tissues; occipital retention should be used; we should correlate treatment with development; function is the most important

factor in retention; the appliances should be removable and not dependent on teeth for retention; overcorrection of all malpositions should be attempted; retention is dependent on bone changes which in turn are related to endocrine dysfunction, functional adaptation of occlusion, and inherent growth; retention is a problem of the apical base limitations; mandibular incisors should be upright over basal bone; possibly there are discrepancies in tooth sizes that cause retention problems; early treatment is more desirable than later treatment; intercanine width and intermolar width should be maintained; it is desirable to achieve muscle balance; one should use mild forces; limitations are imposed on the orthodontist by arch size. With so many principles having been advanced, many based on empirical evidence, there is small wonder that retention remains somewhat of a mystery.

Little, Wallen, and Riedel (1981) assessed postretention relapse in mandibular dentitions of 65 cases greater than five years out of retention. Using the irregularity index (Little, 1975) as a measure of "crowding" they found that neither sex, pretreatment Angle class, length of retention, initial irregularity, age at initiation of treatment, nor any combination of these factors was a useful predictor of the amount of postretention relapse. Swanson, Riedel, and D'Anna (1975), after reviewing 116 postretention cases, concluded that "age, sex, classification, presence of extractions, and growth of the maxilla or mandible had no effect on rotations (relapse) found at the end of the postretention period." They did, however, find that "the amount of relapse experienced by an orthodontically rotated tooth is directly proportional to the amount of rotational correction applied during treatment."

Of the many factors potentially involved in orthodontic relapse, the inability of gingival tissues to accommodate teeth in their corrected positions has recently been strongly implicated. Gingival surgical techniques, gingivectomies and circumferential supracrestal fiberotomies, have been tested in clinical and animal experiments and have shown promising results. These techniques have been advocated for: maintaining extraction sites or diastemas closed; preventing vertical relapses of extruded or intruded teeth; preventing facial or lingual relapse of teeth; and maintaining teeth that have been rotated.

The fiberotomy has been thought to be an effective tool in minimizing rotational relapse and is currently being advocated by many clinicians. The theory behind its use is that the orthodontically stretched supra-alveolar and transseptal fibers provide the necessary forces which tend to rerotate a tooth postorthodontically. By severing these stretched fibers after tooth rotation, it is postulated that the force of rotational relapse is alleviated or diminished. Although a review of the literature concerning studies of fiberotomy efficacy demonstrate impressively that this is a valuable tool for minimizing short term rotational relapse, none of the studies have addressed the <u>long term</u> benefit of this procedure. Perhaps there are so many factors influencing the stability of the dentition that the short term benefit of the fiberotomy is lost over time. This study will attempt to assess whether the apparent short term benefit of the fiberotomy is maintained long term, and if so, whether this long term benefit is of sufficient degree to justify fiberotomy use routinely in clinical settings.

REVIEW OF LITERATURE

I. Arrangement and Characteristics of Principal and Gingival Fibers

The presence of fibers in the periodontal ligament has been known for many years. In his book, Treatment of Malocclusion of the Teeth, Angle (1907) described the location and orientation of these fibers as they related to the dentition. He noted that fibers attatched to the tooth terminated either on alveolar bone, the adjacent tooth, or in the gingiva. He speculated that the periodontal ligament served three functions: vital, sensory, and physical. The physical function held the tooth in place, resisted displacement, and "supported the soft tissues about the teeth." He believed that rotation of a tooth was the second most difficult tooth movement to accomplish orthodontically due to the "unusual number (of fibers) at the four angles so arranged so as to directly resist such movement."

G. V. Black (1936) described a gingival group and transseptal group of fibers. He observed that the gingival fibers "extend outward for a short distance from the cementum, and then turn occlusally and are distributed to the gingivae, where they unite with the fibrous mat which supports the epithelium. This group encircles the tooth completely but is much thicker and stronger on the labial, or buccal, and lingual than on the proximal surfaces." He speculated that this group of fibers functioned in holding the gingiva snugly about the tooth. The transseptal fibers were observed to connect adjacent teeth across a bony septum. These fibers he claimed were necessary to maintain proximal tooth contact from third molar to third molar and thereby bestow health upon the supporting structures.

Goldman (1951) investigated the fibers which comprised "the main bulk of the gingiva" in monkey and human specimens. He noted that some of these fibers, which consisted of collagen, arose from the cementum and terminated in the papillary layer of the gingiva beneath the epithelium. Others traversed the alveolar crest and united with fibers attatched to the outer periosteum. Still other fibers linked adjacent teeth. He observed that the fiber bundles passed outward from the cementum in groups, breaking up into a meshwork of small bundles, the fibers of which interlaced with each other. He postulated that the function of these fibers was to maintain the gingiva closely adapted to the tooth surface, thereby resisting the forces of mastication and preventing apical migration of the epithelial attatchment.

Arnim (1953) studied human, rat, and monkey specimens and observed a dense connective tissue band which encircled the teeth from the alveolar crest occlusally to a level subjacent to the gingival margin. He stated that this circular band was "punctuated by and mingles with the fibers of the free gingival group."

Urban, Beisler, and Skillen (1931) examined the effects of mechanical separation of teeth in dogs. Dental separators in common use at that time were employed to separate teeth "slowly and gradually, ten minutes being allowed in each instance to obtain the desired spacing." These separators were then left in place for thirty minutes and retained while the animal was killed and the tissues fixed. Separations of 0.75 to 2.0 mm were obtained. Histologic examination revealed tearing of the periodontal fibers on the tension side of the periodontal ligaments. They speculated that this tearing of fibers indicated a "nonelastic

quality" and added that after the slack in the fibers is taken up, the breaking point has been approached and only a small amount of further stress will cause tearing. This conclusion that collagenous periodontal ligament fibers are inelastic seems inappropriate. Substantial forces would be necessary to achieve the separations involved. They should have concluded only that their force levels exceeded the elastic limit of the ligament fibers. Their observations were limited to principal and transseptal fibers, i.e. fibers attatched to hard tissues. It would be interesting to know whether the supra-alveolar fibers which terminate in soft tissues revealed the same degree of tearing.

In 1958, Fullmer and Lillie discovered a previously unobserved connective tissue fiber in the periodontal ligament. These fibers were sufficiently different from collagen, elastic, and reticular fibers for recognition as a separate fiber type and were named oxytalan fibers. Fullmer (1959) suggested that these fibers belonged to the same class as elastic fibers and were normal constituents of the periodontal ligament.

Rannie (1963) investigated human, monkey, and rat periodontium and observed that oxytalan fibers near the cemento-enamel junction tended to run parallel to the occlusal plane and in the same direction as the collagen fibers. These fibers were woven between the collagen fibers and he speculated that they imparted added strength to the membrane.

II. The Role of Periodontal Fibers in Orthodontic Relapse

Skogsborg (1927) described a technique he employed clinically to aid retention of his orthodontically treated cases. He believed in accordance with Walkhoff's "tension-difference theory" that the forces causing orthodontic relapse resulted from orthodontically induced

differences of tissue tension in the alveolar process. He held that these tissue tension forces were stored in the buccal and lingual cortical plates of bone surrounding a tooth and were released during the post-orthodontic period. He believed that the technique of septotomy would neutralize these relapse forces. The procedure required making an incision in the mucoperiosteal membranes between "regulated" teeth. A fissure bur was then used to remove the interdental bony cortex from a level just apical to the alveolar crest to a level near the tooth's apex. This procedure was performed on the labial or lingual, three weeks were allowed for healing, then the procedure was repeated on the opposite side of the septum. He showed models of cases in which this procedure had been performed to demonstrate its efficacy, but did not attempt to quantify the degree of benefit of this procedure. Several investigators (Brain, 1969; Collins, 1969) have suggested that the benefit of septotomy in diminishing relapse was probably due to severing of gingival fibers rather than in relieving tension differences in the alveolar process.

Erikson, Kaplan, and Aisenberg (1945) investigated transseptal fibers during orthodontic treatment. Three maxillary and one mandibular first premolar were removed from two human subjects. The canines and second premolars adjacent to these extraction sites were banded and these teeth were then brought into contact. One subject was retained for eleven months and the other for a period of five months. These teeth were then removed in block sections and examined histologically. They observed that: 1) elongated transseptal fibers appear in the spaces created by tooth extraction; 2) when teeth opposite these spaces

are brought into approximation, the transseptal fibers coil and become compressed. "It seems apparent that there exists no physiologic process which shortens or removes the excess of these fibers after the teeth are approximated;" 3) this compression of coiled fibers interdentally could explain the tendency for space reopening; and 4) transseptal fibers are tough and can withstand some stretching as they were observed to pull the teeth to which they were attatched in the direction of the force. Although their study was limited to only two individuals, the observation that transseptal fibers could elongate under tension implies that these fibers may not be as inelastic as Urban (1931) suggested.

Reitan (1959) rotated six upper second incisors in dogs using the first and third incisors as controls. The degree of rotation he estimated to range from fifty to seventy degrees. He retained these teeth for periods varying from 15 to 232 days, then removed them for histologic examination. He observed that although fibers in the middle and apical regions of the roots were "completely rearranged" after 147 days of retention, the marginal region fibers after 232 days of retention were still "stretched in accordance with the previous rotation." Although his sample size was very small, he concluded that "relapse of the rotated tooth after retention seems to be caused primarily by a contraction of displaced gingival fibers and other supra-alveolar structures." This conclusion is highly speculative as he did not include in his study a group which was allowed to relapse prior to histologic examination. It would be interesting to know: 1) would these teeth have relapsed and to what degree, and 2) would this relapse coincide with a

change in marginal fiber orientation?

Heuttner (1960) looked at periodontal fibers of rhesus monkeys undergoing all types of orthodontic tooth movement. From his histologic examination, he concluded that "of all the superficial attatchment fibers, the transseptal fibers seemed to be the most resistant to damage caused by placement of bands on teeth. They also regenerated very rapidly over areas of extraction, tended to elongate easily, and did not necrotize even under severly compressive forces."

Haas (1961) observed spontaneous midline closure of diastemas resulting from palatal expansion in human subjects. This diastema closure took place over a four to six month period after expansion. He suggested that transseptal fibers contained an "elastic element" which would account for this space closure.

Edwards (1968) rotated maxillary second incisors in six young dogs, using the first and third incisors as controls. Prior to rotation, he tattooed the labial gingiva with a vertical series of black dots. After varying periods of rotation and retention, the animals were killed and histologic specimens prepared. He observed that the amount of deviation between the tattoo marks coincided consistently with the amount of tooth rotation, although neither variable was quantified. The attatched gingiva, and to some extent the mucosa, followed in the direction of the rotation. He also noted that the gingiva surrounding the rotated teeth did not reorient itself, as illustrated by the deviated tattoo marks, even after retention of five months. He observed a marked displacement and stretching of the fibrous structures in the free gingival fiber groups with the "most obvious displacement of supracrestal fibers

occurring on the labial and lingual root surfaces. The transseptal fibers of the rotated teeth also showed a consistent displacement." After five months of retention, only the supracrestal and transseptal fibers were disoriented in direction. His specimens stained to reveal oxytalan fibers produced some interesting findings. He saw few oxytalan fibers beneath the transseptal region. "A particularly significant observation during the investigation was the fact that oxytalan fibers, particularly in the supracrestal areas, were definitely more numerous and more clearly defined in the periodontiums of rotated teeth than in those of control teeth. The periods of retention did not eliminate this preponderance of oxytalan in the gingival tissues of the rotated teeth." He speculated that these oxytalan fibers: 1) could have an anchoring effect which would prevent overstretching of the tissue, and 2) might play a role in the tendency for teeth to rerotate postorthodontically.

Schultz (1969) rotated the right and left maxillary second incisors in six dogs. The teeth were passively retained for four to eight weeks. After retention, one of the two incisors of each dog was designated as the experimental tooth, the other serving as a control. Schultz then reduced the crowns of the control teeth to the level of the gingiva to remove occlusal and muscular forces from these teeth. The experimental teeth were reduced to the level of the alveolar bone to remove gingival and transseptal periodontal fiber influences. Pulp caps were placed in these teeth as well as registration wires to study rotational relapse. Using serial radiographs, he found that the mean relapse tendency of the experimental teeth was only 12.4 percent of their original rotation while the mean relapse of the control teeth was 34.6 percent. Although

the sample was small, he believed that "the gingival and transseptal fibers of the periodontal ligament were responsible for at least 50 percent of the relapse of orthodontically rotated teeth." Schultz's methodology was excellent in that he eliminated occlusal and muscular forces as potential relapse factors. Relapse observed could only have resulted from forces within each tooth's supporting structures. Reitan (1959) suggested that a retention period of approximately five months is necessary for complete rearrangement of principal fibers. Had Schultz retained his teeth longer, perhaps one might see a decrease in percent relapse for both experimental and control teeth.

Boese (1969) rotated eight lateral incisors and eight second premolars in two pigtailed monkeys. At the beginning of retention, half of these teeth were gingivectomized while the other half served as controls. These teeth were then retained for 4, 8, and 9 weeks; the postretention periods involved were 4 and 8 weeks. Occlusal radiographs were used to calculate rotation. He identified two phases of orthodontic relapse: 1) during the first four weeks after rotation, he believed that a substantial proportion of observed relapse was due to relaxation of strethed principal fibers, and 2) after the first eight weeks, he felt that relapse was caused by the supra-alveolar fibers. He observed, as Edwards had, that oxytalan fibers increased in areas of orthodontic tooth rotation and believed that "overrotation and prolonged retention would be ineffective for preventing rotational relapse." Relapse in Boese's gingivectomized group was completed within four weeks postretention. Crum and Andreasen (1974), however, found rotational relapse in several fiberotomized individuals continuing between 4 and 8 weeks postretention.

This may suggest that principal fibers influence relapse for a longer period of time postretention than has been suggested by Boese.

Allen (1969) investigated regression of rotated teeth in a human sample. His sample included seventeen patients averaging 14.6 years in age. Each patient had one pair of bilaterally rotated teeth. The teeth were rotated orthodontically into proper alignment. Gingivectomies were performed around the experimental teeth and the control and experimental teeth were retained from periods of 2 to 14 months, with a mean of 9 months. The teeth were then analyzed for rotational relapse up to three months postretention from Xerox copies of casts made at six different time periods. After three months of postretention observation, Allen found that the surgical group demonstrated a mean relapse of 13.4 percent while the control group mean relapse was 31.5 percent. He concluded that the supra-alveolar fibers contributed to regression of orthodontically rotated teeth and that gingivectomy was beneficial in reducing the effects of these fibers. He realized the weakness in his study was that some teeth were retained for only two months and that perhaps the principal fibers of these teeth had not yet reorganized at the time of retention release. As his sample size was small, the difference in percent relapse between groups was not significant at a probability of five percent. Contrary to the observations of Edwards and Boese, Allen did not witness an increase in oxytalan fibers in the supra-alveolar tissues.

Collins (1969) investigated the effect of the gingival fibers on teeth that were tipped and on teeth that were orthodontically spaced. In two Macaca mulatta monkeys, he tipped one mandibular central incisor

and the contralateral lateral incisor labially while tipping the other two incisors lingually. In the maxillary arches of these monkeys, the central incisors were orthodontically separated approximately five millimeters. One animal was designated the test animal and received gingivectomies around the anterior teeth in both arches. The other served as a control. Both animals were then retained for six weeks, after which appliances were removed and relapse recorded. After three weeks of observation, the mandibular incisors of the control animal had relapsed 78 percent while the experimental animal had relapsed 52 percent. The observation of the orthodontically induced maxillary diastemas revealed a control relapse of 78 percent compared to a relapse of 61 percent for the experimental animal. Although samples were so small that the results were not statistically significant, Collins concluded that surgical removal of displaced gingival tissues decreased the rate of relapse of tipped or separated incisors but did not prevent relapse. He erred in not retaining the teeth longer and also in not observing the teeth longer postorthodontically.

Brain (1969) analyzed rotational relapse in five mongrel dogs. The maxillary second incisors were rotated orthodontically. The right second incisors were surgerized on their labial and lingual surfaces in an attempt to transsect the free gingival fibers, the left second incisors were not surgerized and served as controls. The teeth were then retained for 148 to 150 days and released. At the conclusion of a six week observation period, the extent of regression in the control group ranged from 8.8 to 40 percent with a mean of 26.7 percent. The regression of the surgerized group ranged from 0 to 5.3 percent with a mean

of 1.1 percent. He found a very promising regression ratio of 24 to 1. He concluded that "the results of this investigation confirm the findings of previous researchers who have reported less regression of orthodontically rotated incisors subsequent to interruption of the free gingival fibers." It is difficult to comprehend how Brain could have achieved such remarkable stability in his experimental group. He did use a retention period which, according to Reitan, was adequate to allow principal fiber reorganization. This might account for some of the stability, but it would seem that labial and lingual incisions would not adequately inactivate the supra-alveolar fibers which completely encircle teeth.

Edwards (1970) orthodontically rotated sixteen malrotated teeth in clinical patients, the extent of malrotation varying from 20 to 90 degrees. Prior to rotating these teeth, a vertical series of dots was tattooed on the buccal or labial attatched gingiva with India ink. He observed that in every instance, the amount of deviation from the original vertical orientation of the marks coincided with the amount of rotational movement of the tooth. After all teeth were experimentally rotated, they were retained for two months, and half of the teeth were removed from the archwires. All eight of these teeth relapsed to some degree with the tattoo lines reverting toward their original vertical orientation. These eight teeth were then rerotated. Eight weeks of retention followed and then fiberotomies were performed on all 16 teeth. After the fiberotomies had been performed, the tattoo marks returned to a vertical orientation after 20 to 40 hours on fifteen of the teeth. The one tooth which did not show this realignment of tattoos was

resurgerized with special emphasis placed on deepening the incision below the marginal crest. Within 28 hours after the second surgery, the tattoo marks of this tooth were again vertically oriented. He observed all teeth for three months and noted "negligible rotational relapse occurred, even in the case of teeth that were earlier observed to have relapsed." Unfortunately, Edwards did not quantify the degree of rotation and relapse. It would have been beneficial to know to what extent a given tooth relapsed prior to and subsequent to fiberotomy.

Parker (1972) extracted mandibular first molars bilaterally in seven female monkeys. The second bicuspids were partially retracted bilaterally into the edentulous space. Gingivectomies were then performed unilaterally on each monkey extending from the buccal grooves of the second molar to the center of the first premolar. All teeth were then retained for thirty days and then the appliances were removed. One animal was sacrificed at the time of appliance removal, others at 12 hours, 24 hours, 2, 4, 30, and 60 days. He observed that the control sides showed relapse of the second premolars mesially in all animals; whereas, the surgical sides showed marked stability. He also found that the greatest relapse occurred in the first 24 hours. He concluded that supragingival fibers, especially transseptal fibers, were the cause of the observed relapse. This conclusion, although possibly accurate, is speculative as gingivectomy removes the influence of all gingival components. Other forces within the tissues, e.g. hydrostatic pressure, may have accounted for some of the relapse in the non-gingivectomized group.

Pinson and Strahan (1973) compared relapse of 21 rotated anterior

teeth that had received pericision (fiberotomy) postorthodontically with 10 rotated anterior teeth that did not receive pericision postorthodontically. After a minimum of one year postretention, they found that the surgerized teeth relapsed on average 25.5 percent of their original rotation while the non-surgerized teeth relapsed a mean of 56.6 percent. They noted that the degree and percentage of relapse of the surgerized teeth was markedly reduced if the teeth were retained for more than 16 weeks. Although the experimental and control groups were small and the results were not tested for significance, this was the first study which assessed rotational relapse beyond three months postretention.

In a study by Crum (1974), five subjects were investigated averaging 16.4 years in age. Each had bilaterally rotated anterior teeth, three on each side of the midline. The rotations were corrected orthodontically and all teeth were retained for eight weeks. Teeth on one side of the midline of each patient then received a fiberotomy while those on the other side of the midline served as controls. The teeth were then released from retention and observed for up to eight weeks. Crum found a mean relapse of rotation in the experimental group of 1.45 degrees (10.8%) with five of the fifteen teeth rotating away from the pretreatment tooth position. Rotational relapse of the control teeth showed a mean of 10.5 degrees (48.4%). He concluded that the circumferential gingival fiber cut combined with an adequate period of retention is a successful approach to reduce postretention tooth rotation. The majority of teeth investigated by Crum revealed rotational changes during the interval from 4 to 8 weeks postretention. It would seem erroneous to assume that no further relapse would have occurred had observations

been continued beyond 8 weeks postretention.

Walsh (1975) subjected 23 teenaged patients (31 teeth) to pericision. The only criterion for selection was that they required correction of rotation of a maxillary anterior tooth during the course of their orthodontic treatment. He noted that the effectiveness of the surgical transsection improved with increasing lengths of retention. Two cases that had no retention relapsed an average of 75 percent. Those teeth retained from two to twelve weeks showed a mean relapse of only 27 percent. Those teeth retained from thirteen to twenty weeks showed a mean relapse of only 9 percent. The number of teeth in each group was small, but Walsh felt that corrected rotations should be retained for at least twelve weeks.

Boese (1980) found that by combining fiberotomy with posttreatment reproximation, he could effectively achieve long term (4 to 9 years posttreatment) reduction of mandibular anterior irregularity. In forty patients with crowded mandibular arches who were treated orthodontically, he noted a significant mean decrease in irregularity posttreatment. None of these patients had mandibular arch retention. Although Boese addressed the long term problem of relapse as it relates to fiberotomy, it would be impossible to separate the effect of fiberotomy from that of reproximation in his sample.

A few studies have concluded that displaced gingival fibers do not influence dental relapse. Brauer (1963) and Tsopel (1967) could not recommend surgical resection of fibers based on their tooth rotation studies. In both studies, however, the sample sizes were small and the teeth were not retained postrotation. Their results might be a

reflection of the importance of retention in allowing principal fibers to reorganize.

Although the literature abounds with studies pertaining to the relationship between periodontal fibers and rotational relapse, none of the studies conducted have analyzed this relationship long term. This study will attempt to assess whether the clinical application of the fiberotomy technique will enhance rotational stability long term.

MATERIALS AND METHODS

The materials used in this study consisted of pretreatment (T_1), posttreatment (T_2), and postretention (T_3) plaster casts obtained from patients who had been treated either in the UW Orthodontic Clinic or in the private practice of Dr. Richard Riedel. Individuals were selected to participate in this study using the following criteria:

1) Pretreatment, posttreatment, and greater than two years postretention casts must have been available for both experimental and control group participants.
2) Participants included in the experimental group must have had a documented fiberotomy performed on one or more anterior teeth either shortly before or after the completion of active orthodontic treatment. Documentation was established by: a) actual charting of the procedure as well as teeth involved, and b) recollection of the fiberotomy procedure by the participant.
3) Participants included in the control group must not have undergone a fiberotomy or gingivectomy procedure either during or after treatment involving any of the teeth included in the study.
4) Control and experimental group participants must have worn retainers postorthodontically for a minimum of six months.
5) Control and experimental group participants must have been more than two years postretention with a similar mean period of time postretention. The experimental group was collected initially and was found to range from 2.58 to 9.17 years postretention. In selecting the control group, efforts were made to include

only those individuals who fell near or within this range.

6) The teeth under study, experimental and control, must have undergone a treatment rotation of ten degrees or more as determined by a preliminary measurement using an Unitek Baum Cephalometric Protractor.

All patients involved in this study were treated with conventional edgewise mechanics. Only mandibular and maxillary incisors and canines were evaluated in the study. An experimental group was obtained which consisted of 73 teeth (22 patients) while 91 teeth (26 patients) comprised the control group, (table 1).

	$\underline{1}$	$\underline{2}$	$\underline{3}$	$\overline{1}$	$\overline{2}$	$\overline{3}$	Total
Experimental	18	20	10	10	6	9	73
Control	21	24	11	8	14	13	91

Table 1: Frequency Distribution of Experimental and Control Teeth by Tooth Category

In order to compare the stability of fiberotomized vs. non-fiberotomized teeth, it was necessary to quantify the amount of treatment rotation and posttreatment rotation of each tooth. As this is difficult to assess on plaster casts, photocopies of each T_1, T_2, and T_3 cast were made using a technique developed by Singh and Savara (1964). They reported that duplicated graph paper showed no enlargement in the middle ten square centimeters of a Xerox copier. A template was, therefore, fabricated which allowed accurate centering and consistent positioning of all models placed on the copier (Xerox 4000).

Prior to photocopying, the casts were marked with a black fine-tipped marker. Each cast in a series was marked sequentially to allow greater accuracy in the placement of points. Two points were placed on the incisal edge of each tooth under investigation: one point approximately one millimeter mesial to the distoincisal angle and one point approximately one millimeter distal to the mesioincisal angle. When photocopied, these tooth points would allow a measurement of the rotational position of the tooth involved relative to a fixed (midline) reference line. This fixed reference line was constructed in the maxillary arch by placing two points on the median raphae: one just distal to the incisive papilla and another a given distance distal to this first marking. At this point the maxillary and mandibular casts were photocopied and the images revealed the markings previously made.

As the mandibular cast has no equivalent to the maxilla's raphae, it was necessary to transfer the maxillary reference line to the mandibular photocopy. This was accomplished by inverting and superimposing the mandibular photocopy onto the maxillary photocopy on a viewbox. When the posterior bases of the models' images were made to coincide, the maxillary midline points could be transferred to the mandibular photocopy. This midline transfer is not entirely accurate as a lateral shift of the mandible could cause a change in placement of this mandibular reference line over time; however, it was deemed sufficiently accurate for this study.

Angles were constructed by connecting the reference line points and tooth points using a 0.3 mm 2H tracing pencil. A protractor calibrated in 0.5 degree increments was used to determine angular measure-

ments of individual teeth relative to their respective reference lines. The photocopies were randomized prior to measuring to elliminate bias and each tooth was measured at three different time periods: T_1, T_2, and T_3. Each measurement was made on two occasions and these values were averaged to minimize measurement error. Variables involved in this study included:

V_1 - rotational change occurring during treatment measured in degrees. This value was always positive and represented a change toward good arch alignment, (figure 1).

V_2 - rotational change occurring during the posttreatment to postretention interval. This measurement was negative if the tooth under investigation rotated back toward its original position or positive if it rotated away from its original position, (figure 1).

V_3 - stability of treatment rotation. This value measured the percentage of treatment rotation maintained at the postretention period. This value was positive unless the tooth in question relapsed more than 100 percent, (figure 1).

The reliability of the technique was tested as follows:

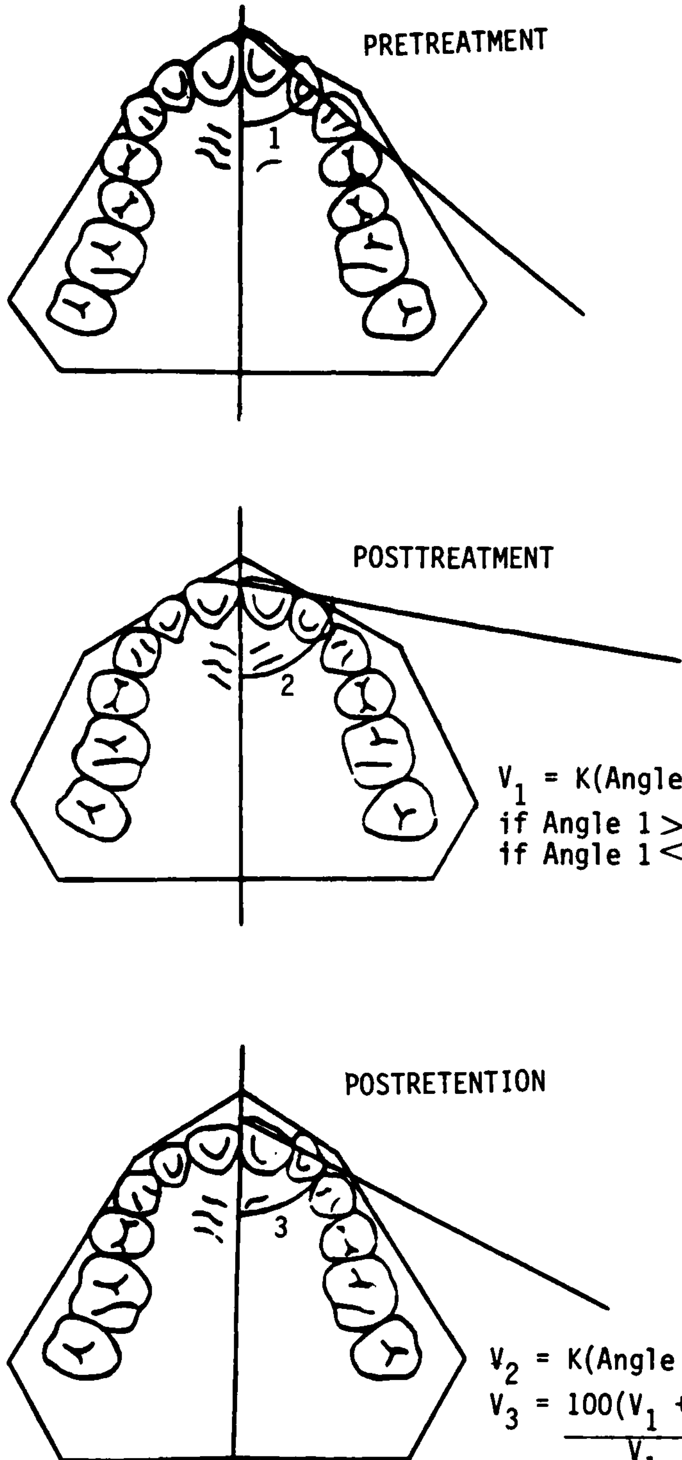
1) Two sets of casts were duplicated yielding 49 identical tooth pairs. One tooth from each identical pair was placed in the M_1 (measure 1) group while the second tooth was placed in the M_2 group.
2) Each tooth pair was marked with two points. Incisors and canines were marked in the fashion previously described. Premolars and molars were marked on cusp tips. Each tooth pair

was marked sequentially with emphasis placed on locating the markings similarly on each tooth in an identical pair.

3) Casts were photocopied. These photocopies were then randomized and angular tooth measurements were made.

A close association, as determined by Pearson product moment correlation, was found to exist between angular measurements made on identical tooth pairs, ($r = .99$, $p \leq .01$). A mean absolute difference of 2.4 degrees was found to exist between M_1 and M_2 measurements. This indicates that the average error inherent in the entire technique, i.e. point placement, photocopying, marking, and measuring, was only $\pm$ 2.4 degrees.

To determine the significance of the difference between control and experimental tooth groups, t tests were utilized. Correlational and analysis of variance statistical tests were employed to determine whether the variables of T_1 age, T_2 age, T_3 age, treatment length, retention length, time postretention, time posttreatment, or type of treatment could account for any observed difference in stability.



$$V_1 = K(\text{Angle 2} - \text{Angle 1})$$
if Angle 1 $>$ Angle 2, $K = -1$
if Angle 1 $<$ Angle 2, $K = 1$

$$V_2 = K(\text{Angle 3} - \text{Angle 2})$$
$$V_3 = \frac{100(V_1 + V_2)}{V_1}$$

Figure 1: Method for determining treatment rotation, relapse of rotation, and stability

FINDINGS

Measurements made from photocopies of dental casts provided data which was pooled for comparison between experimental and control groups. These pooled data groups were then divided into three subgroups--maxillary incisors, mandibular incisors, and canines--for further analysis, (tables 2-7, figures 2-10).

I. Pooled Data

The experimental, fiberotomized sample revealed a treatment rotation ranging from 8.2 to 53.4 degrees with a mean of 19.5 degrees. The range of treatment rotation for the control, non-fiberotomized group was 8.4 to 43.6 degrees with a mean of 17.6 degrees. Mean treatment rotation was found not to be significantly different between groups, ($p > .05$).

Relapse of rotation for the experimental group ranged from -18.3 to 9.1 degrees with a mean relapse of -4.6 degrees. Fifty-nine experimental teeth (81%) relapsed back toward their pretreatment positions. Fourteen experimental group teeth (19%) rotated away from their original positions. The control sample revealed a mean relapse of -7.1 degrees, ranging from -19.9 to 5.7 degrees. Eighty-one control group teeth (89%) relapsed toward their pretreatment positions while 10 control teeth (11%) relapsed away from their original positions. Mean relapse of rotation was significantly different between the control and experimental groups, ($p \leq .01$).

The stability of the experimental group, i.e. the percentage of treatment rotation maintained at the postretention period, ranged from -20.4 to 169.7 percent with a mean of 77.2 percent. The control group stability ranged from -77.1 to 163.8 percent with a mean stability of

61.0 percent. Stated conversely, the mean relapse percentage for the experimental group was 22.8 percent compared to 39.0 percent for the control group. The regression ratio expressed in terms of mean relapse percentage of the control group vs. the experimental group was found to be 1.7 to 1. Stability was found to be significantly different between groups, ($p \leq .01$).

As the fiberotomized group was found to be significantly more stable than the control group, it became necessary to determine whether any intergroup differences, aside from fiberotomy, could account for this difference in stability. T tests revealed that the variables of post-treatment age and length of retention were not significantly different between groups and hence probably did not influence the observed stability difference. The variables which were found to be significantly different between groups included: pretreatment age, postretention age, treatment length, time posttreatment, and time postretention. Analysis of covariance was used to determine if the difference in stability between experimental and control teeth was still present after adjusting for these intergroup differences. The analysis of covariance indicated that the difference in stability was still statistically significant, ($p \leq .01$).

Pearson product moment correlations between stability and the variables of T_1 age, T_2 age, T_3 age, treatment length, retention length, time posttreatment, and degrees of treatment rotation were made independently for the control and experimental groups. None of these variables revealed a clinically usable correlation with stability. Treatment length did, however, reveal a very weak association with stability

for the experimental group, ($r = .36$, $p \leq .01$). This weak association was not evident for the control group, ($r = .07$, $p > .05$).

Information gleaned from analysis of variance tests revealed that: 1) there was no difference in stability between arches; 2) there existed no difference in stability between tooth categories; and 3) there was a significant difference in stability between types of treatment, i.e. nonextraction treatment, extraction of first premolars, or extraction of second premolars; however, this difference between types of treatment could not explain the observed difference in stability between the experimental and control groups. Mean stability was greatest for the first premolar extraction group and least for the second premolar extraction group. This relationship was found to exist for both the experimental and control groups but must be viewed with some skepticism as both the second premolar extraction group and the nonextraction group had small sample sizes.

II. Maxillary Incisors

The experimental group underwent a mean treatment rotation of 19.3 degrees with a range from 8.2 to 46.7 degrees. The control group revealed a mean treatment rotation of 17.8 degrees ranging from 8.4 to 32.9 degrees. The difference in treatment rotation between groups was not statistically significant, ($p > .05$).

A mean relapse of rotation of -3.5 degrees was found for the fiberotomized group ranging from -18.3 to 9.1 degrees. The control group showed a mean relapse of -7.3 degrees with a range from -17.2 to 4.0 degrees.

The experimental sample displayed a mean stability of 83.1 percent

with a range from 16.7 to 169.7 percent. The control sample stability ranged from -3.6 to 140.2 percent with a mean of 61.9 percent. Although a t test revealed a statistically significant difference between groups, ($p \leq .01$), when analysis of covariance was used taking the intergroup difference in treatment length into account, stability was found not to be significantly different, ($p > .05$).

III. Mandibular Incisors

The mandibular incisor experimental group underwent a mean treatment rotation of 20.4 degrees ranging from 10.8 to 53.4 degrees. Treatment rotation for the control group ranged from 8.9 to 43.6 degrees with a mean of 18.0 degrees. Mean treatment rotation was not significantly different between groups, ($p > .05$).

A mean relapse of rotation of -6.3 degrees was observed for the experimental group which ranged from -15.5 to 4.7 degrees. The control group mean relapse of rotation was -6.9 degrees and ranged from -19.8 to 5.7 degrees. Mean relapse of rotation was not significantly different between groups, ($p > .05$).

The mean stability of the experimental group was 68.5 percent ranging from 16.9 to 128.0 percent. The control group displayed a mean stability of 58.0 percent with a range from -77.1 to 163.8 percent. The intergroup difference in mean stability was not statistically significant, ($p > .05$).

IV. Canines

The experimental group revealed a mean treatment rotation of 19.3 degrees with a range from 9.0 to 47.6 degrees. The control group had a treatment rotation mean of 16.9 degrees and ranged from 8.7 to 32.3

degrees. Treatment rotation was not significantly different between groups, ($p > .05$).

Relapse of rotation for the experimental group displayed a mean of -5.4 degrees ranging from -16.6 to 3.2 degrees. The control group relapse of rotation ranged from -19.9 to 3.9 degrees with a mean of -6.9 degrees. There was not a statistically significant difference in means for relapse of rotation, ($p > .05$).

The experimental group mean stability was 72.7 percent and ranged from -20.4 to 127.3 percent. The control group stability ranged from 10.0 to 126.3 percent with a mean stability of 62.0 percent. The mean stability was not significantly different between groups, (p . .05).

Patient/ Tooth	Age T_1 (Yrs)	Age T_2 (Yrs)	Age T_3 (Yrs)	Tx Length (Yrs)	Ret Length (Yrs)	Time PostTx (Yrs)	Time PostRet (Yrs)	Tx	Tooth Angulation T_1 (Degrees)	Tooth Angulation T_2 (Degrees)	Tooth Angulation T_3 (Degrees)	V_1 = Tx Rotation (Degrees)	V_2 = Relapse Rotation (Degrees)	V_3 = Stability (Percent)
XXX 1/	15.25	18.50	27.50	2.92	3.00	9.00	6.00	4	115.9	90.4	95.1	25.6	- 4.7	81.6
HBA /1	12.58	16.92	24.25	3.25	1.83	8.08	6.33	4	58.7	75.6	72.5	16.9	- 3.1	81.6
QQU 1/	10.92	13.92	27.00	2.75	7.00	13.25	6.00	4	33.7	80.4	74.4	46.7	- 6.1	87.0
QQU /1	10.92	13.92	27.00	2.75	7.00	13.25	6.00	4	62.0	79.4	77.6	17.4	- 1.8	89.7
HOH /1	12.00	14.00	21.08	1.50	1.50	7.50	6.00	4	61.4	81.2	69.9	19.8	-11.3	42.9
HKJ /1	12.75	14.00	22.83	0.92	3.00	9.00	5.50	NE	54.5	73.6	62.9	19.1	-10.7	43.8
HEW 1/	14.25	17.25	25.42	2.83	2.58	8.25	5.67	4	103.5	88.3	93.1	15.2	- 4.8	68.8
HHO /1	11.92	14.17	21.25	1.58	1.50	7.67	6.17	NE	58.8	67.2	62.9	8.4	- 4.3	48.8
HFH 1/	11.42	13.75	22.58	1.50	2.75	8.92	6.17	4	65.5	80.0	83.6	14.5	+ 3.6	124.8
HFH /1	11.42	13.75	22.58	1.50	2.75	8.92	6.17	4	60.5	79.0	80.0	18.5	+ 1.0	105.1
HQO 1/	16.00	21.08	25.00	3.33	1.50	5.42	3.92	4	80.1	70.7	72.4	9.4	- 1.7	81.9
BAX 1/	12.17	15.08	24.08	3.75	2.50	9.00	6.50	NE	71.2	84.7	82.6	13.5	- 2.1	84.4
HQO /1	16.00	21.08	25.00	3.33	1.50	5.42	3.92	4	99.7	88.7	86.3	11.0	+ 2.5	122.3
BAX /1	12.17	15.08	24.08	3.75	2.50	9.00	6.50	NE	60.6	73.7	82.8	13.1	+ 9.1	169.7
RBTO 1/	13.58	16.00	22.83	1.25	2.50	6.75	4.25	5	60.0	83.9	74.4	23.9	- 9.5	60.2
RBTO /1	13.58	16.00	22.83	1.25	2.50	6.75	4.25	5	50.6	79.9	65.7	29.4	-14.3	51.5
HBX 1/	11.67	14.00	23.33	1.67	3.83	9.83	6.00	NE	54.5	75.4	69.4	20.9	- 6.0	71.3
HBX /1	11.67	14.00	23.33	1.67	3.83	9.83	6.00	NE	54.9	75.3	73.1	20.4	- 2.2	89.2
QQU 2/	10.92	13.92	27.00	2.75	7.00	13.25	6.00	4	26.6	56.8	58.6	30.2	+ 1.9	106.1
QQU /2	10.92	13.92	27.00	2.75	7.00	13.25	6.00	4	19.0	53.8	52.8	34.8	- 1.0	97.1
HOH 2/	12.00	14.00	21.08	1.50	1.50	7.50	6.00	4	23.1	45.6	47.8	22.5	+ 2.3	110.0
HOH /2	12.00	14.00	21.08	1.50	1.50	7.50	6.00	4	50.9	61.2	58.6	10.4	- 2.7	74.4
HKJ 2/	12.75	14.00	22.83	0.92	3.00	9.00	5.50	NE	39.7	47.9	48.7	8.2	+ 0.8	109.8
HSB /2	12.17	14.33	20.42	2.08	1.00	6.08	5.00	NE	66.6	57.3	57.5	9.3	- 0.2	98.4
HEW 2/	14.25	17.25	25.42	2.83	2.58	8.25	5.67	4	83.5	66.4	68.8	17.1	- 2.5	85.7
HEW /2	14.25	17.25	25.42	2.83	2.58	8.25	5.67	4	70.8	58.4	59.1	12.4	- 0.7	94.4
HHO /2	11.92	14.17	21.25	1.58	1.50	7.67	6.17	NE	39.1	51.6	50.1	12.5	- 1.5	88.4
HFH /2	11.42	13.75	22.58	1.50	2.75	8.92	6.17	4	29.4	51.5	48.0	22.1	- 3.5	84.2
VWP /2	12.33	14.67	26.58	2.17	6.00	11.83	5.00	4	17.0	46.1	45.5	29.1	- 0.7	97.8
HQO 2/	16.00	21.08	25.00	3.33	1.50	5.42	3.92	4	7.6	48.9	44.6	41.3	- 4.3	89.7
HQO /2	16.00	21.08	25.00	3.33	1.50	5.42	3.92	4	27.0	49.3	46.4	22.3	- 2.9	87.0
BAX 2/	12.17	15.08	24.08	3.75	2.50	9.00	6.50	NE	47.1	59.4	55.0	12.3	- 4.4	64.1
ZZK /2	11.83	17.00	25.50	4.17	3.00	8.58	5.58	4	38.2	50.6	49.2	12.4	- 1.4	89.1
RBTO /2	13.58	16.00	22.83	1.25	2.50	6.75	4.25	5	27.6	49.5	31.2	21.9	-18.3	16.7
HQR 2/	12.25	14.00	20.33	1.33	1.50	6.25	4.75	5	70.8	45.5	61.7	25.3	-16.2	36.0
HQR /2	12.25	14.00	20.33	1.33	1.50	6.25	4.75	5	66.1	48.5	55.6	17.7	- 7.1	59.8
SSZ 2/	13.92	15.67	26.58	1.50	5.92	10.75	5.00	4	35.4	49.3	49.5	13.9	+ 0.2	101.1
SSZ /2	13.92	15.67	26.58	1.50	5.92	10.75	5.00	4	39.0	54.7	49.0	15.7	- 5.7	63.6
MEANS	12.82	15.61	23.92	2.25	3.05	8.59	5.48					19.3	- 3.5	83.1
S.D.	1.53	2.28	2.17	0.94	1.83	2.23	0.83					8.8	5.4	27.9

Table 2: Experimental Group, Maxillary Incisors

Patient/ Tooth	Age T_1 (Yrs)	Age T_2 (Yrs)	Age T_3 (Yrs)	Tx Length (Yrs)	Ret Length (Yrs)	Time PostTx (Yrs)	Time PostRet (Yrs)	Tx	Tooth Angulation T_1 (Degrees)	Tooth Angulation T_2 (Degrees)	Tooth Angulation T_3 (Degrees)	V_1 = Tx Rotation (Degrees)	V_2 = Relapse Rotation (Degrees)	V_3 = Stability (Percent)
HKW 1/	12.42	13.75	22.50	1.00	6.00	8.75	2.58	4	68.0	80.9	84.5	12.9	+ 3.6	127.9
UUK 1/	13.42	18.92	28.58	2.08	3.83	13.00	9.17	4	67.3	77.3	73.2	10.1	- 4.2	58.7
UUK /1	13.42	18.92	28.58	2.08	3.83	13.00	9.17	4	65.5	74.8	71.8	9.3	- 3.0	67.7
HX /1	13.75	15.58	23.75	1.58	1.25	8.25	7.00	4	53.1	75.0	69.6	21.9	- 5.4	75.3
HU /1	14.58	16.00	24.42	1.17	1.58	8.58	7.00	4	60.5	72.3	70.6	11.8	- 1.7	85.6
JI 1/	12.50	14.92	17.50	1.25	1.08	3.58	2.50	4	61.6	72.8	65.9	11.2	- 6.9	38.6
JI /1	12.50	14.92	17.50	1.25	1.08	3.58	2.50	4	67.2	76.4	63.9	9.2	- 6.6	28.8
HG 1/	14.33	16.08	22.25	0.83	0.75	6.58	5.83	4	63.0	73.4	70.3	10.5	- 3.1	70.3
JD /1	12.00	13.25	20.00	0.75	2.00	7.08	5.08	4	55.1	70.8	59.6	15.8	-11.2	28.9
HQ /1	10.42	11.92	18.17	0.67	4.17	6.92	2.75	NE	60.9	69.2	68.8	8.4	- 0.4	95.2
RBAU 1/	13.00	13.92	24.83	0.83	5.17	10.92	5.75	4	62.2	84.5	68.5	22.3	-16.0	28.1
RBAU /1	13.00	13.92	24.83	0.83	5.17	10.92	5.75	4	58.2	88.7	71.0	30.5	-17.7	42.0
RBIH 1/	14.08	15.00	23.17	0.83	2.17	8.08	5.92	4	65.2	81.0	79.0	15.8	- 2.1	87.0
RBIH /1	14.08	15.00	23.17	0.83	2.17	8.08	5.92	4	56.6	72.9	72.1	16.4	- 0.8	95.1
IT 1/	12.50	13.92	24.17	1.33	3.83	10.25	6.42	4	58.7	70.1	70.4	11.5	+ 0.3	102.6
IT /1	12.50	13.92	24.17	1.33	3.83	10.25	6.42	4	60.7	78.0	75.4	17.3	- 2.7	84.7
KD 1/	12.50	15.25	23.42	1.58	2.92	9.25	6.33	4	59.2	74.1	70.0	14.9	- 4.1	72.5
RAJN 1/	13.08	14.00	24.67	0.83	2.92	10.67	7.75	4	67.1	88.4	77.3	21.4	-11.1	48.0
RAJN /1	13.08	14.00	24.67	0.83	2.92	10.67	7.75	4	59.7	90.0	73.4	30.3	-16.7	45.1
RAPM 1/	15.25	18.00	27.17	1.42	1.58	9.17	7.58	4	58.7	80.8	72.5	22.1	- 8.3	62.4
RAPM /1	15.25	18.00	27.17	1.42	1.58	9.17	7.58	4	60.5	84.0	70.7	23.5	-13.3	43.6
HKW /2	12.42	13.75	22.50	1.00	6.00	8.75	2.58	4	38.1	56.5	41.0	18.4	-15.6	15.5
HNB 2/	15.33	18.33	25.00	2.67	3.00	6.75	3.00	4	72.9	61.4	62.7	11.5	- 1.3	89.1
UUK 2/	13.42	18.92	28.58	2.08	3.83	13.00	9.17	4	76.4	43.5	57.7	32.9	-14.2	56.8
UUK /2	13.42	18.92	28.58	2.08	3.83	13.00	9.17	4	56.9	43.4	51.8	13.5	- 8.4	37.9
CL 2/	12.33	14.33	19.08	1.83	1.25	4.75	3.50	5	71.1	52.6	61.6	18.5	- 9.0	51.4
HX 2/	13.75	15.58	23.75	1.58	1.25	8.25	7.00	4	73.4	60.4	58.9	13.0	+ 1.5	111.2
HU 2/	14.58	16.00	24.42	1.17	1.58	8.58	7.00	4	58.3	48.0	53.1	10.4	- 5.1	50.7
JD /2	12.00	13.25	20.00	0.75	2.00	7.08	5.08	4	12.5	35.5	31.5	23.0	- 4.0	82.6
HQ 2/	10.42	11.92	18.17	0.67	4.17	6.92	2.75	NE	76.3	55.9	72.0	20.5	-16.2	21.0
RBEZ 2/	13.50	15.17	25.00	0.83	3.50	9.83	6.33	4	21.8	52.4	40.2	30.6	-12.2	60.3
RAXV 2/	12.92	14.50	25.50	1.00	5.83	11.00	5.17	4	58.5	41.4	56.5	17.1	-15.1	11.7
RAXV /2	12.92	14.50	25.50	1.00	5.83	11.00	5.17	4	61.5	44.9	62.1	16.6	-17.2	-3.6
RBAU 2/	13.00	13.92	24.83	0.83	5.17	10.92	5.75	4	20.6	42.5	30.7	21.9	-11.8	46.0
RBAU /2	13.00	13.92	24.83	0.83	5.17	10.92	5.75	4	41.8	61.1	52.7	19.3	- 8.4	56.6
RBIH 2/	14.08	15.00	23.17	0.83	2.17	8.08	5.92	4	79.1	56.5	63.6	22.6	- 7.1	68.7
RBIH /2	14.08	15.00	23.17	0.83	2.17	8.08	5.92	4	63.6	52.3	59.0	11.4	- 6.7	41.0
IT 2/	12.50	13.92	24.17	1.33	3.83	10.25	6.42	4	[illegible].0	52.4	48.3	14.5	- 4.2	71.3
IT /2	12.50	13.92	24.17	1.33	3.83	10.25	6.42	4	16.3	45.9	43.9	29.6	- 2.0	93.4
KD 2/	12.50	15.25	23.42	1.58	2.92	9.25	6.33	4	63.0	53.0	49.0	10.0	+ 4.0	140.2
RBEX /2	13.92	15.33	24.92	1.33	2.58	9.50	6.92	4	72.0	58.9	60.2	13.1	- 1.3	90.0
RAJN 2/	13.08	14.00	24.67	0.83	2.92	10.67	7.75	4	51.7	61.9	59.5	10.3	- 2.5	76.1
RAJN /2	13.08	14.00	24.67	0.83	2.92	10.67	7.75	4	[illegible]6.2	68.0	53.6	31.9	-14.4	54.8
RAPM 2/	15.25	18.00	27.17	1.42	1.58	9.17	7.58	4	72.0	48.5	65.3	23.6	-16.8	28.7
RAPM /2	15.25	18.00	27.17	1.42	1.58	9.17	7.58	4	73.1	54.0	64.5	19.[illegible]	-10.5	45.3
MEANS	13.26	15.22	23.94	1.22	3.08	9.17	6.06					17.8	- 7.3	61.9
S.D.	1.12	1.87	2.85	0.47	1.51	2.20	1.88					6.9	6.1	30.5

Table 3: Control Group, Maxillary Incisors

Patient/ Tooth	Age T_1 (Yrs)	Age T_2 (Yrs)	Age T_3 (Yrs)	Tx Length (Yrs)	Ret Length (Yrs)	Time PostTx (Yrs)	Time PostRet (Yrs)	Tx	Tooth Angulation T_1 (Degrees)	Tooth Angulation T_2 (Degrees)	Tooth Angulation T_3 (Degrees)	V_1 = Tx Rotation (Degrees)	V_2 = Relapse Rotation (Degrees)	V_3 = Stability (Percent)
HKW $\overline{1\|}$	12.42	13.75	22.50	1.00	6.00	8.75	2.58	4	71.1	84.1	87.7	13.1	+3.6	127.2
HKW $\overline{\|1}$	12.42	13.75	22.50	1.00	6.00	8.75	2.58	4	70.4	85.1	73.4	14.7	-11.7	20.4
HNB $\overline{\|1}$	15.33	18.33	25.00	2.67	3.00	6.75	3.00	5	92.7	81.9	80.7	10.8	+ 1.3	111.6
HSB $\overline{1\|}$	12.17	14.33	20.42	2.08	1.00	6.08	5.00	NE	94.7	83.6	92.5	11.2	- 8.9	20.2
HNO $\overline{1\|}$	11.92	14.17	21.25	1.58	1.50	7.67	6.17	NE	59.4	76.0	68.6	16.6	- 7.4	55.7
HNO $\overline{\|1}$	11.92	14.17	21.25	1.58	1.50	7.67	6.17	NE	99.2	84.1	92.1	15.1	- 8.1	46.7
HFH $\overline{\|1}$	11.42	13.75	22.58	1.50	2.75	8.92	6.17	4	65.7	82.3	86.9	16.6	+ 4.7	128.0
ZZK $\overline{\|1}$	11.83	17.00	25.50	4.17	3.00	8.58	5.58	4	65.6	85.1	79.6	19.6	- 5.6	71.6
RBTO $\overline{1\|}$	13.58	16.00	22.83	1.25	2.50	6.75	4.25	5	58.8	77.4	61.9	18.6	-15.5	16.9
HQR $\overline{\|1}$	12.25	14.00	20.33	1.33	1.50	6.25	4.75	5	110.8	81.0	92.6	29.8	-11.6	61.0
HPQ $\overline{2\|}$	13.58	17.08	22.50	3.00	1.00	5.58	4.50	4	47.4	64.7	61.8	17.3	- 2.9	83.2
HSB $\overline{\|2}$	12.17	14.33	20.42	2.08	1.00	6.08	5.00	NE	44.3	62.3	50.3	18.0	-12.1	33.1
HFH $\overline{2\|}$	11.42	13.75	22.58	1.50	2.75	8.92	6.17	4	81.7	67.1	67.4	14.6	- 0.3	97.9
HCZ $\overline{\|2}$	13.92	16.67	25.17	1.58	0.50	9.50	9.00	4	107.3	53.9	63.4	53.4	- 9.5	82.3
HQR $\overline{2\|}$	12.25	14.00	22.33	1.33	1.50	6.25	4.75	5	91.9	65.0	74.4	26.9	- 9.4	65.2
HQR $\overline{\|2}$	12.25	14.00	22.33	1.33	1.50	6.25	4.75	5	87.3	57.2	64.8	30.1	- 7.6	74.9
MEANS	12.56	14.94	22.47	1.81	2.31	7.42	5.03					20.4	- 6.3	68.5
S.D.	1.04	1.52	1.61	0.84	1.64	1.31	1.60					10.6	5.9	36.0

Table 4: Experimental Group, Mandibular Incisors

Patient/ Tooth	Age T_1 (Yrs)	Age T_2 (Yrs)	Age T_3 (Yrs)	Tx Length (Yrs)	Ret Length (Yrs)	Time PostTx (Yrs)	Time PostRet (Yrs)	Tx	Tooth Angulation T_1 (Degrees)	Tooth Angulation T_2 (Degrees)	Tooth Angulation T_3 (Degrees)	V_1 = Tx Rotation (Degrees)	V_2 = Relapse Rotation (Degrees)	V_3 = Stability (Percent)
XXX $\overline{\|1}$	15.25	18.50	27.50	2.92	3.00	9.00	6.00	5	104.5	85.5	93.0	19.1	- 7.5	60.6
UUK $\overline{1\|}$	13.42	18.92	28.58	2.08	3.83	13.00	9.17	4	60.3	77.2	72.6	16.9	- 4.6	72.7
UUK $\overline{\|1}$	13.42	18.92	28.58	2.08	3.83	13.00	9.17	4	63.9	85.2	83.3	21.4	- 2.0	90.9
HEI $\overline{1\|}$	13.33	15.83	24.67	2.25	1.83	9.00	7.17	4	65.0	73.9	79.5	8.9	+ 5.7	163.8
CL $\overline{1\|}$	12.33	14.33	25.25	1.83	3.25	10.83	7.67	5	100.8	91.4	101.0	9.4	- 9.6	- 2.1
HU $\overline{1\|}$	14.58	16.00	24.42	1.33	2.08	8.42	6.33	NE	68.9	83.6	74.4	14.8	- 9.3	37.3
FC $\overline{1\|}$	11.50	15.17	23.58	3.50	2.42	8.42	6.00	5	91.4	78.0	90.9	13.5	-13.0	3.7
RAPM $\overline{1\|}$	15.25	18.00	27.17	1.42	1.58	9.17	7.58	4	94.8	78.6	86.7	16.2	- 8.1	49.9
HEI $\overline{2\|}$	13.33	15.83	24.67	2.25	1.83	9.00	7.17	4	39.1	51.9	49.7	12.8	- 2.2	82.8
BAX $\overline{2\|}$	12.17	15.08	24.08	3.75	2.50	9.00	6.50	NE	78.0	54.4	64.2	23.6	- 9.8	58.5
BAX $\overline{\|2}$	12.17	15.08	24.08	3.75	2.50	9.00	6.50	NE	73.6	58.8	69.6	14.9	-10.9	26.9
ZZK $\overline{2\|}$	11.83	17.00	25.50	4.17	3.00	8.58	5.58	4	81.9	59.2	64.3	22.8	- 5.1	77.6
FC $\overline{2\|}$	11.50	15.17	23.58	3.50	2.42	8.42	6.00	5	86.0	60.0	70.5	26.1	-10.5	59.7
JD $\overline{2\|}$	12.00	13.25	20.00	0.75	1.42	7.08	5.67	4	46.2	55.9	53.6	9.8	- 2.4	75.9
JD $\overline{\|2}$	12.00	13.25	20.00	0.75	1.42	7.08	5.67	4	46.3	57.4	37.7	11.2	-19.8	-77.1
RAXV $\overline{\|[illegible]}$	12.92	14.50	25.50	1.00	5.83	11.00	5.17	4	46.2	61.3	64.8	15.1	+ 3.6	123.6
RBEN $\overline{2\|}$	13.33	14.67	24.42	1.25	3.83	9.75	5.92	4	84.6	64.9	60.5	19.7	+ 4.4	122.3
RBEN $\overline{\|2}$	13.33	14.67	24.42	1.25	3.83	9.75	5.92	4	49.2	68.7	60.7	19.5	- 8.0	59.0
RBAU $\overline{\|2}$	13.00	13.92	24.83	0.83	1.75	10.92	9.17	4	76.1	62.9	71.6	13.2	- 8.7	34.1
RBIH $\overline{\|2}$	14.08	15.00	23.17	0.83	2.17	8.08	5.92	4	76.1	60.9	73.6	15.2	-12.7	16.5
RAPM $\overline{2\|}$	15.25	18.00	27.17	1.42	1.58	9.17	7.58	4	95.2	65.1	74.2	30.1	- 9.2	69.6
RAPM $\overline{\|2}$	15.25	18.00	27.17	1.42	1.58	9.17	7.58	4	122.3	78.8	92.1	43.6	-13.3	69.5
MEANS	13.24	15.87	24.92	2.02	2.61	9.40	6.79					18.0	- 6.9	58.0
S.D.	1.26	1.80	2.26	1.11	1.10	1.55	1.22					7.9	6.2	49.3

Table 5: Control Group, Mandibular Incisors

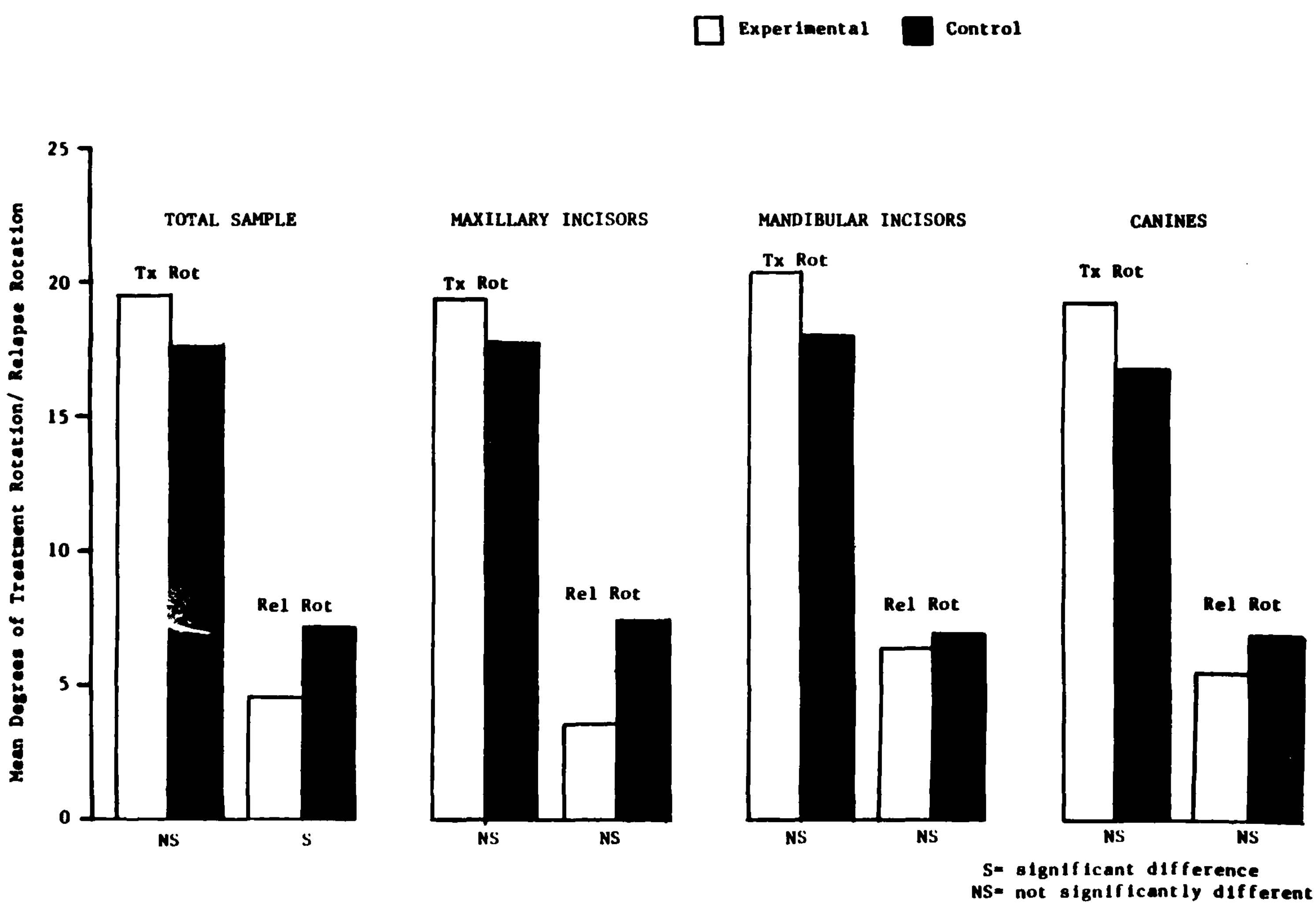
Patient/ Tooth	Age T_1 (Yrs)	Age T_2 (Yrs)	Age T_3 (Yrs)	Tx Length (Yrs)	Ret Length (Yrs)	Time PostTx (Yrs)	Time PostRet (Yrs)	Tx	Tooth Angulation T_1 (Degrees)	Tooth Angulation T_2 (Degrees)	Tooth Angulation T_3 (Degrees)	V_1 = Tx Rotation (Degrees)	V_2 = Relapse Rotation (Degrees)	V_3 = Stability (Percent)
HBA /3	12.58	16.92	24.25	3.25	1.83	8.08	6.33	4	14.3	25.8	29.0	11.6	+ 3.2	127.3
HOH 3/	12.00	14.00	21.08	1.50	1.50	7.50	6.00	4	70.2	38.5	46.0	31.7	- 7.5	76.3
HKJ 3/	12.75	14.00	22.83	0.92	3.00	9.00	5.50	NE	52.5	25.4	35.5	27.1	-10.1	62.7
HFH 3/	11.42	13.75	22.58	1.50	2.75	8.92	6.17	4	53.4	27.5	35.8	25.9	- 8.3	68.1
HFH /3	11.42	13.75	22.58	1.50	2.75	8.92	6.17	4	38.5	29.0	31.2	9.5	- 2.2	76.7
VAP 3/	12.33	14.67	26.58	2.17	6.00	11.83	5.00	4	51.0	34.8	32.5	16.2	+ 2.3	114.2
VAP /3	12.33	14.67	26.58	2.17	6.00	11.83	5.00	4	46.3	31.7	39.7	14.7	- 8.1	45.1
RBTO 3/	13.58	16.00	22.83	1.25	2.50	6.75	4.25	5	23.8	43.2	38.3	19.4	- 4.9	74.7
RBTO /3	13.58	16.00	22.83	1.25	2.50	6.75	4.25	5	46.0	32.2	48.8	13.8	-16.6	-20.4
SSZ 73	13.92	15.67.	26.58	1.50	5.92	10.75	5.00	4	22.0	38.4	33.7	16.4	- 4.7	71.3
HBA 37	12.58	16.92	24.25	3.25	1.83	8.08	6.33	4	12.4	30.8	29.7	18.4	- 1.1	94.0
HBA /3	12.58	16.92	24.25	3.25	1.83	8.08	6.33	4	11.3	33.6	30.4	22.4	- 3.2	85.7
HVN 37	11.67	14.17	19.25	1.42	2.25	5.75	3.08	NE	8.8	32.3	30.1	23.5	- 2.2	90.6
HVN /3	11.67	14.17	19.25	1.42	2.25	5.75	3.08	NE	17.2	29.0	25.8	11.8	- 3.2	73.2
HFH 37	11.42	13.75	22.58	1.50	2.75	8.92	6.17	4	45.6	35.5	35.0	10.1	+ 0.6	105.5
HFH /3	11.42	13.75	22.58	1.50	2.75	8.92	6.17	4	22.4	35.4	26.5	13.1	- 8.9	31.8
HCZ /3	13.92	16.67	25.17	1.58	0.50	9.50	9.00	4	52.3	27.9	38.1	24.4	-10.2	58.2
RBTO /3	13.58	16.00	22.83	1.25	2.50	6.75	4.25	5	3.5	51.1	35.0	47.6	-16.2	66.1
SSZ /3	13.92	15.67	26.58	1.50	5.92	10.75	5.00	4	40.1	31.1	32.9	9.0	- 1.8	79.9
MEANS	12.56	15.13	23.45	1.77	3.02	8.57	5.43					19.3	- 5.4	72.7
S D.	0.94	1.23	2.23	0.72	1.66	1.83	1.37					9.5	5.5	31.9

Table 6: Experimental Group, Canines

Patient/ Tooth	Age T_1 (Yrs)	Age T_2 (Yrs)	Age T_3 (Yrs)	Tx Length (Yrs)	Ret Length (Yrs)	Time PostTx (Yrs)	Time PostRet (Yrs)	Tx	Tooth Angulation T_1 (Degrees)	Tooth Angulation T_2 (Degrees)	Tooth Angulation T_3 (Degrees)	V_1 = Tx Rotation (Degrees)	V_2 = Relapse Rotation (Degrees)	V_3 = Stability (Percent)
JI 3/	12.50	14.92	17.50	1.25	1.08	3.58	2.50	4	42.1	29.8	36.5	12.3	- 6.7	45.7
RBEZ 3/	13.50	15.17	25.00	0.83	3.50	9.83	6.33	4	47.4	19.4	35.4	28.0	-16.0	43.0
RBEZ /3	13.50	15.17	25.00	0.83	3.50	9.83	6.33	4	59.4	31.9	38.7	27.6	- 6.9	75.1
RBEN 3/	13.33	14.67	24.42	1.25	3.83	9.75	5.92	4	52.5	22.9	37.7	29.7	-14.9	49.9
RBEN 73	13.33	14.67	24.42	1.25	3.83	9.75	5.92	4	49.0	32.5	37.1	16.5	- 4.7	71.8
RBAU 3/	13.00	13.92	24.83	0.83	5.17	10.92	5.75	4	34.2	23.9	30.4	10.4	- 6.5	37.2
RBKE 3/	12.92	13.92	21.08	0.92	2.33	7.25	4.92	4	57.7	49.0	48.3	8.7	+ 0.7	108.1
KD /3	12.50	15.25	23.42	1.58	2.92	9.25	6.33	4	0.3	15.1	19.0	14.9	+ 3.9	126.3
RBEX 73	13.92	15.33	24.92	1.33	2.58	9.50	6.92	4	48.0	28.8	36.5	19.2	- 7.7	59.9
RAJN 3/	13.08	14.00	24.67	0.83	2.92	10.67	7.75	4	49.9	35.7	43.8	14.2	- 8.1	43.3
RAJN /3	13.08	14.00	24.67	0.83	2.92	10.67	7.75	4	50.4	39.0	43.1	11.4	- 4.1	64.3
UUK 37	13.42	18.92	28.58	2.08	3.83	13.00	9.17	4	22.2	35.0	35.3	12.8	+ 0.3	102.3
UUK /3	13.42	18.92	28.58	2.08	3.83	15.00	9.17	4	38.2	21.2	30.2	17.1	- 9.1	46.9
HEI 37	13.33	15.83	24.67	2.25	1.83	9.00	7.17	4	39.3	25.5	28.3	13.8	- 2.8	79.7
HEI /3	13.33	15.83	24.67	2.25	1.83	9.00	7.17	4	38.8	28.1	34.8	10.7	- 6.7	37.1
FC 37	11.50	15.17	23.58	3.50	2.42	8.42	6.00	5	60.1	39.4	55.1	20.7	-15.7	24.2
FC /3	11.50	15.17	23.58	3.50	2.42	8.42	6.00	5	58.1	48.9	49.6	9.3	- 0.7	92.4
RBEZ /3	13.50	15.17	25.00	0.83	3.50	9.83	6.33	4	6.0	18.0	11.5	12.0	- 6.5	45.8
RAXV 37	12.92	14.50	25.50	1.00	5.83	11.00	5.17	4	7.7	22.9	20.7	15.3	- 2.2	85.6
RAXV /3	12.92	14.50	25.50	1.00	5.83	11.00	5.17	4	0.2	32.4	12.5	32.3	-19.9	38.3
RBEN 37	13.33	14.67	24.42	1.25	3.83	9.75	5.92	4	51.4	29.9	35.1	2[illegible].5	- 5.2	75.8
RBIN /3	14.08	15.00	23.17	0.83	2.17	8.08	5.92	4	50.0	35.0	48.5	15.0	-13.5	10.0
RAJN /3	13.08	14.00	24.67	0.83	2.92	10.67	7.75	4	35.1	47.7	45.5	12.6	- 2.2	82.9
RAPH 37	15.25	18.00	27.17	1.42	1.58	9.17	7.58	4	11.0	31.3	19.7	20 [illegible]	-11.6	43.0
MEANS	13.18	15.25	24.54	1.44	3.18	9.64	6.46					16.9	- 6.9	62.0
S.D.	0.75	1.41	2.18	0.79	1.23	1.87	1.41					6.7	5.9	28.3

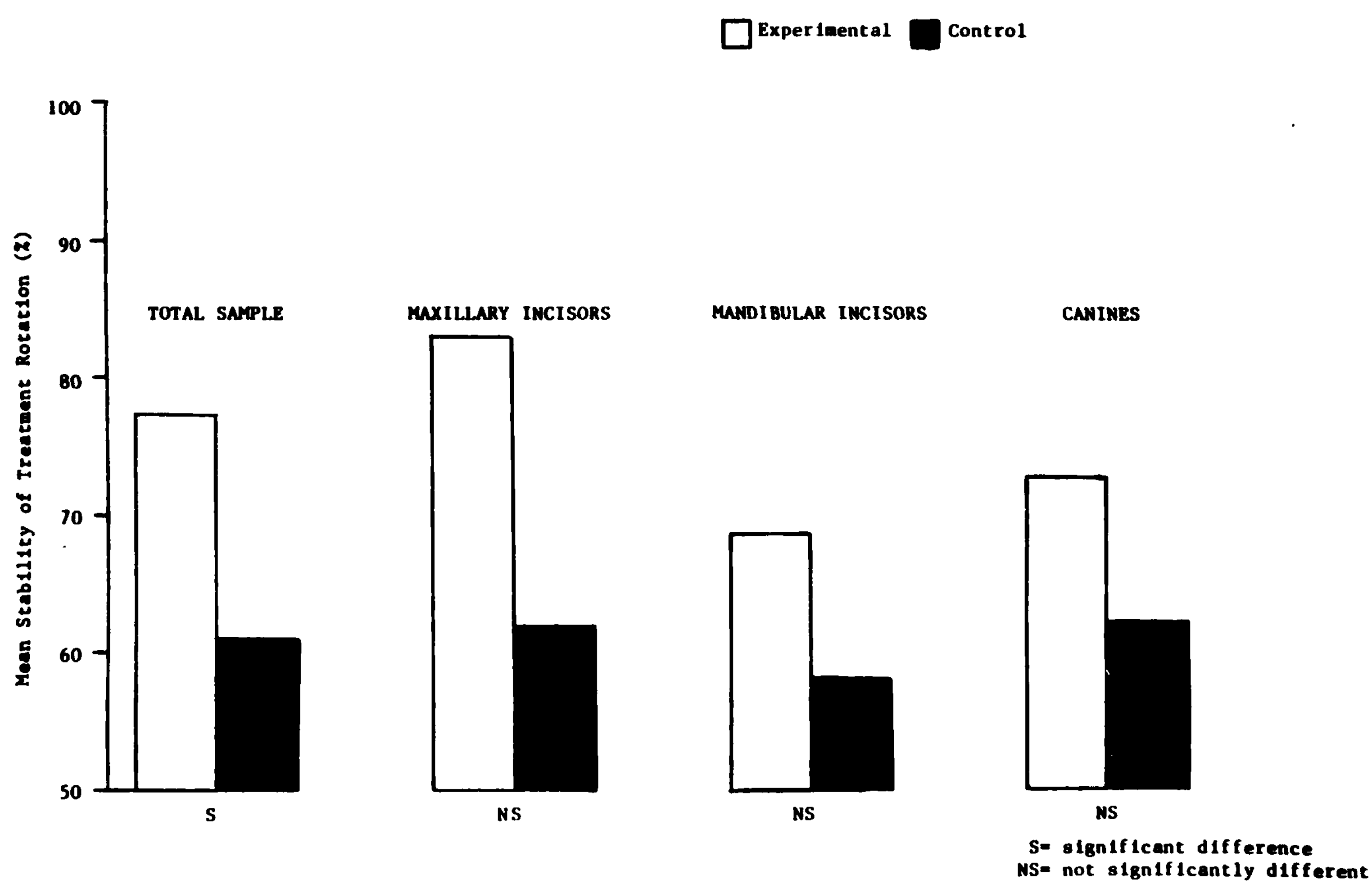
Table 7: Control Group, Canines

Figure 2: Chart showing differences in mean treatment rotation and mean relapse of rotation between experimental and control groups.



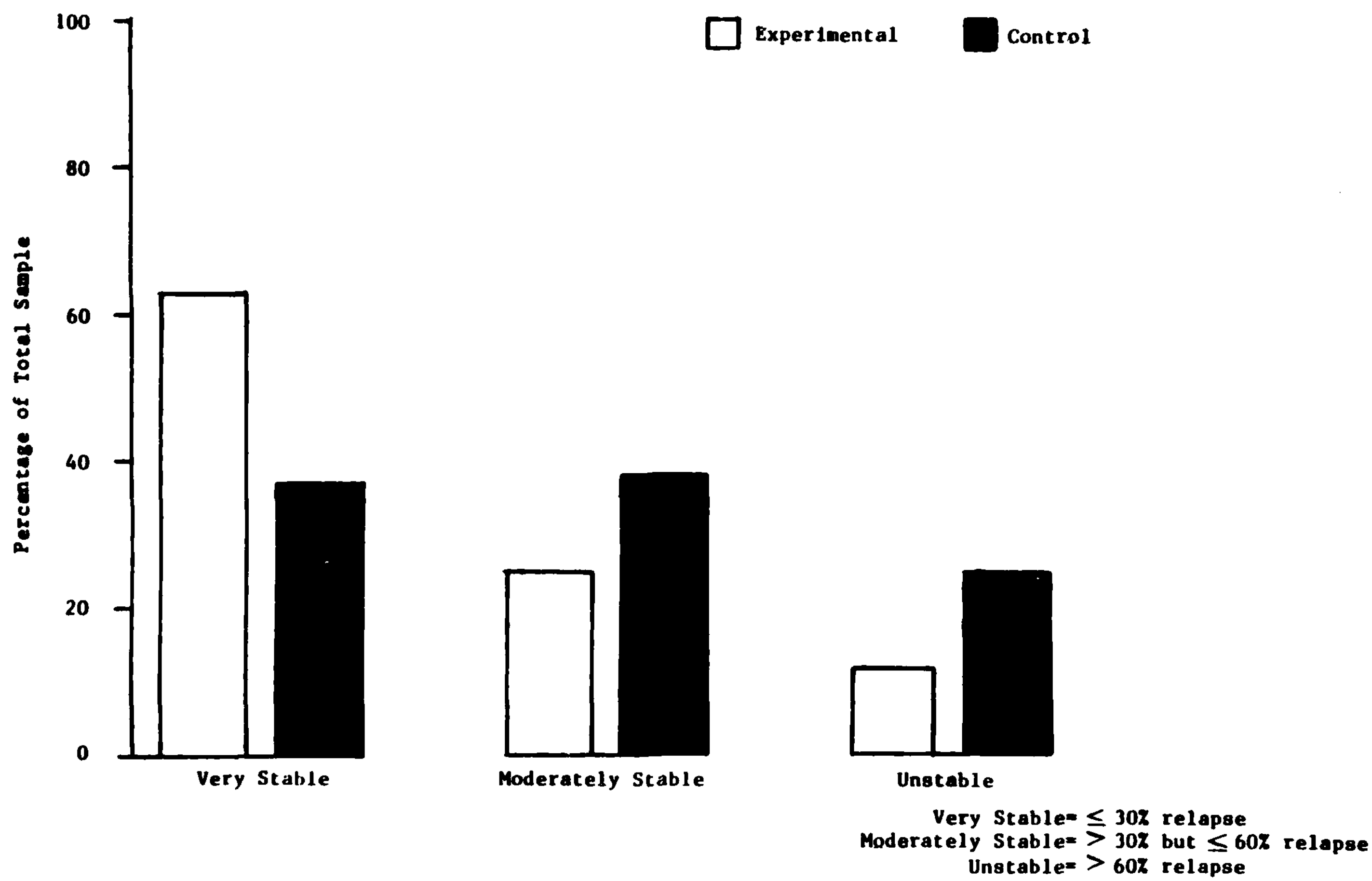
Experimental
Control
Mean Degrees of Treatment Rotation/ Relapse Rotation
25
20
15
10
5
0
TOTAL SAMPLE
MAXILLARY INCISORS
MANDIBULAR INCISORS
CANINES
Tx Rot
Rel Rot
NS
S
S= significant difference
NS= not significantly different

Figure 3: Chart illustrating differences in mean stability of treatment rotation between experimental and control groups.



Experimental
Control
Mean Stability of Treatment Rotation (%)
100
90
80
70
60
50
TOTAL SAMPLE
MAXILLARY INCISORS
MANDIBULAR INCISORS
CANINES
S
NS
NS
NS
S= significant difference
NS= not significantly different

Figure 4: Chart illustrating percentages of the total sample falling within three arbitrarily defined stability groups.



Experimental
Control
100
80
60
40
20
0
Percentage of Total Sample
Very Stable
Moderately Stable
Unstable
Very Stable= ≤ 30% relapse
Moderately Stable= > 30% but ≤ 60% relapse
Unstable= > 60% relapse

Figure 5: Chart illustrating percentages of maxillary incisors falling within three arbitrarily defined stability groups.

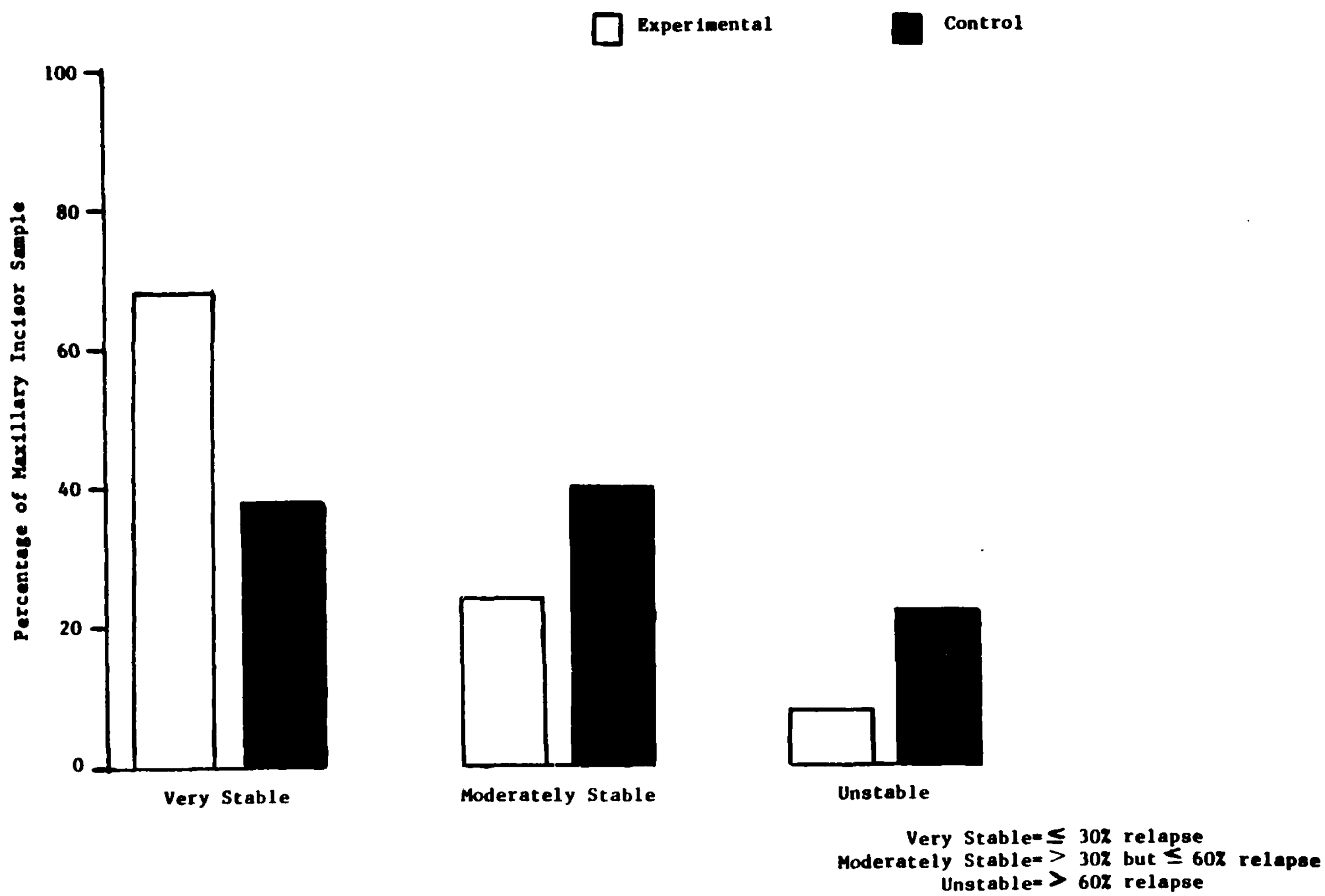
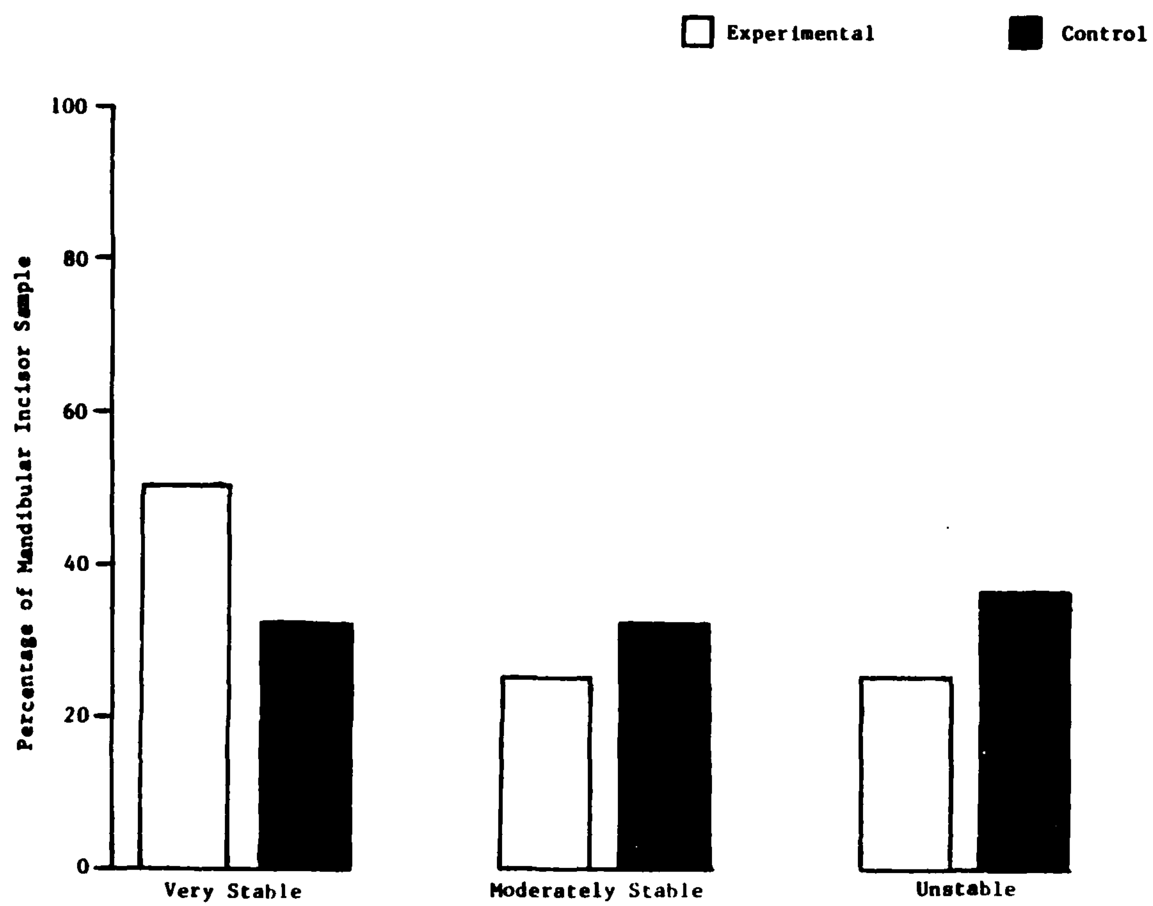
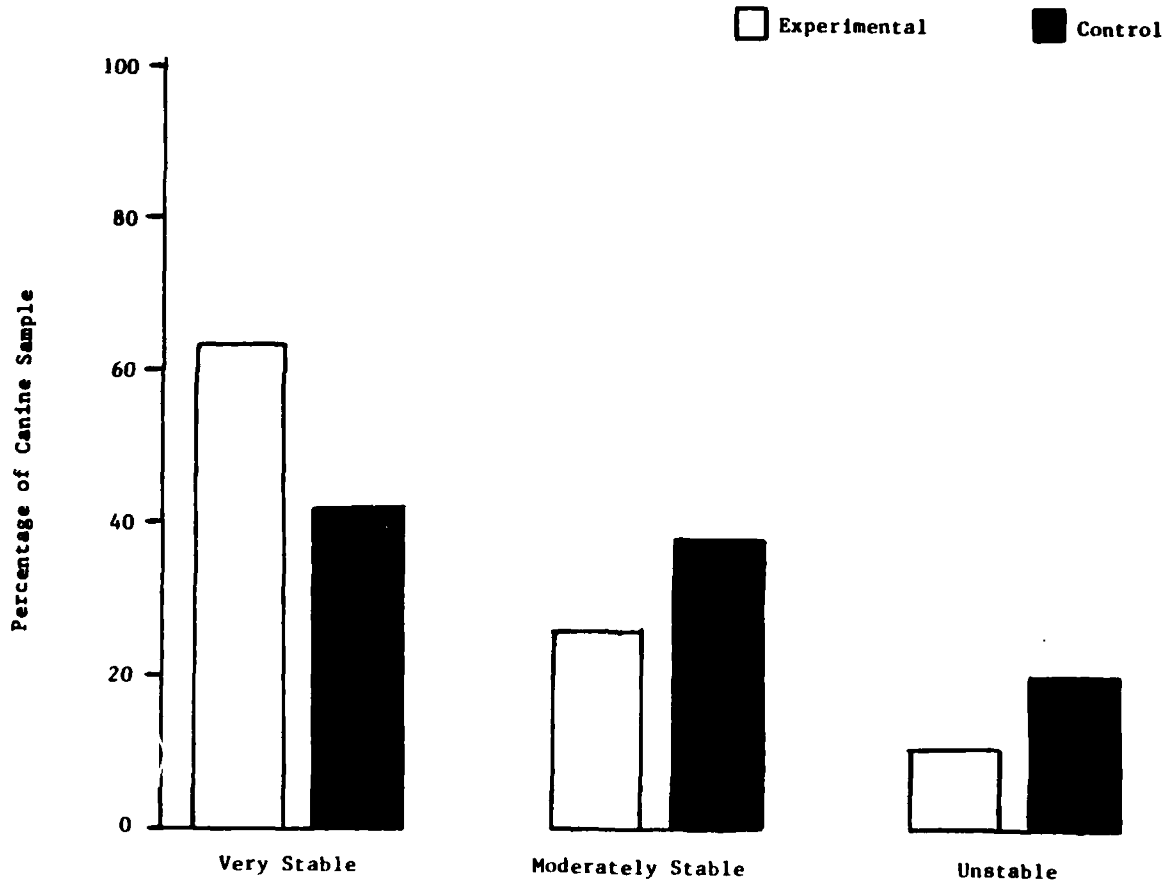

Experimental
Control
100
80
60
40
20
0
Percentage of Maxillary Incisor Sample
Very Stable
Moderately Stable
Unstable
Very Stable= ≤ 30% relapse
Moderately Stable= > 30% but ≤ 60% relapse
Unstable= > 60% relapse

Figure 6: Chart illustrating percentages of mandibular incisors falling within three arbitrarily defined stability groups.



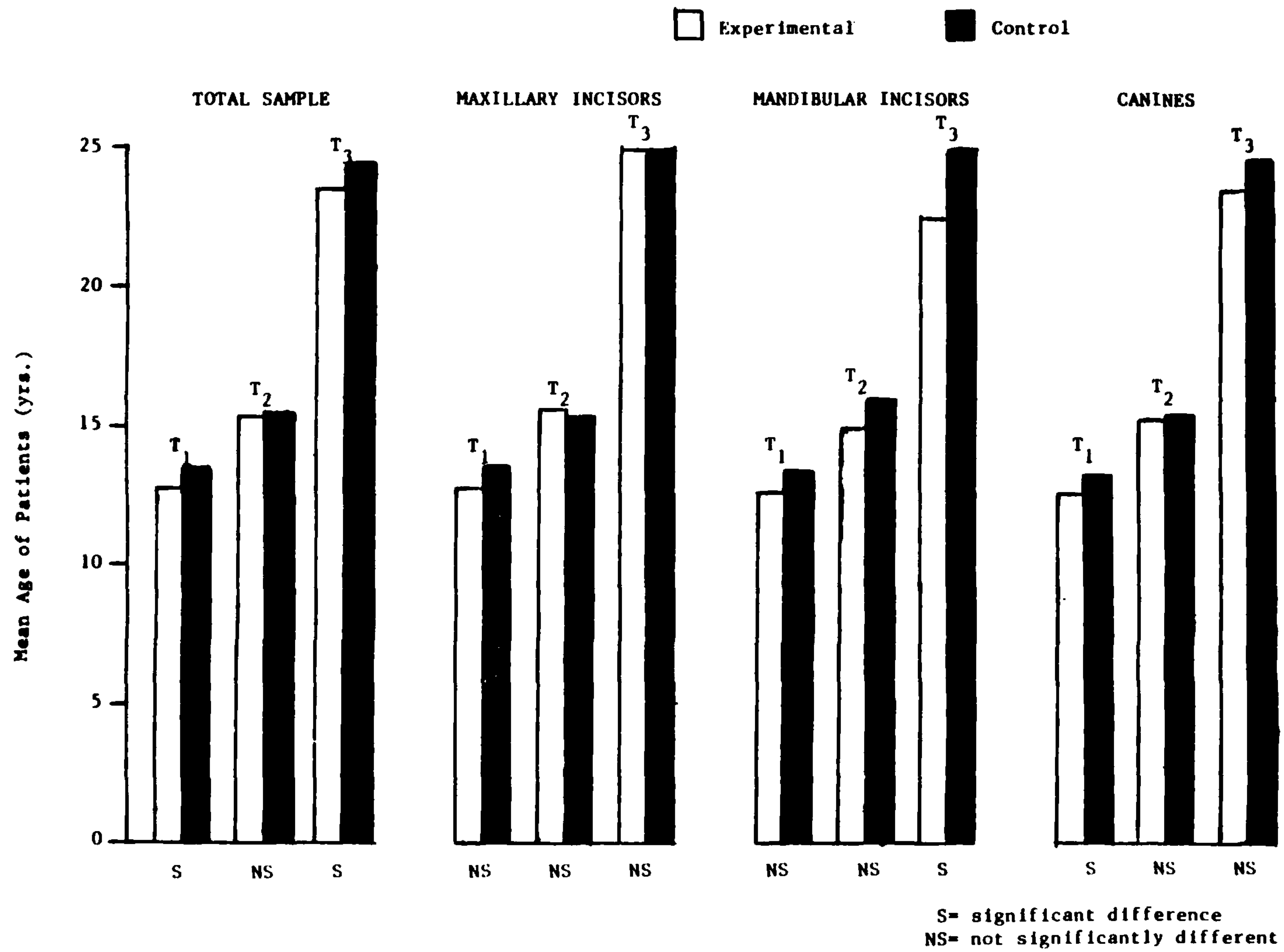
Very Stable= $\leq$ 30% relapse
Moderately Stable= $>$ 30% but $\leq$ 60% relapse
Unstable= $>$60% relapse

Figure 7: Chart illustrating percentages of canines falling within three arbitrarily defined stability groups.



Very Stable= ≤ 30% relapse
Moderately Stable= > 30% but ≤ 60% relapse
Unstable= > 60% relapse

Figure 8: Chart illustrating differences in mean ages between experimental and control groups at three time periods: T_1 = prior to treatment; T_2 = end of treatment; T_3 = postretention.



Experimental
Control
TOTAL SAMPLE
MAXILLARY INCISORS
MANDIBULAR INCISORS
CANINES
Mean Age of Patients (yrs.)
25
20
15
10
5
0
T_1
T_2
T_3
S
NS
S
NS
NS
NS
NS
NS
S
S
NS
NS
S= significant difference
NS= not significantly different

Figure 9: Chart showing differences in mean length of treatment and mean length of retention between experimental and control groups.

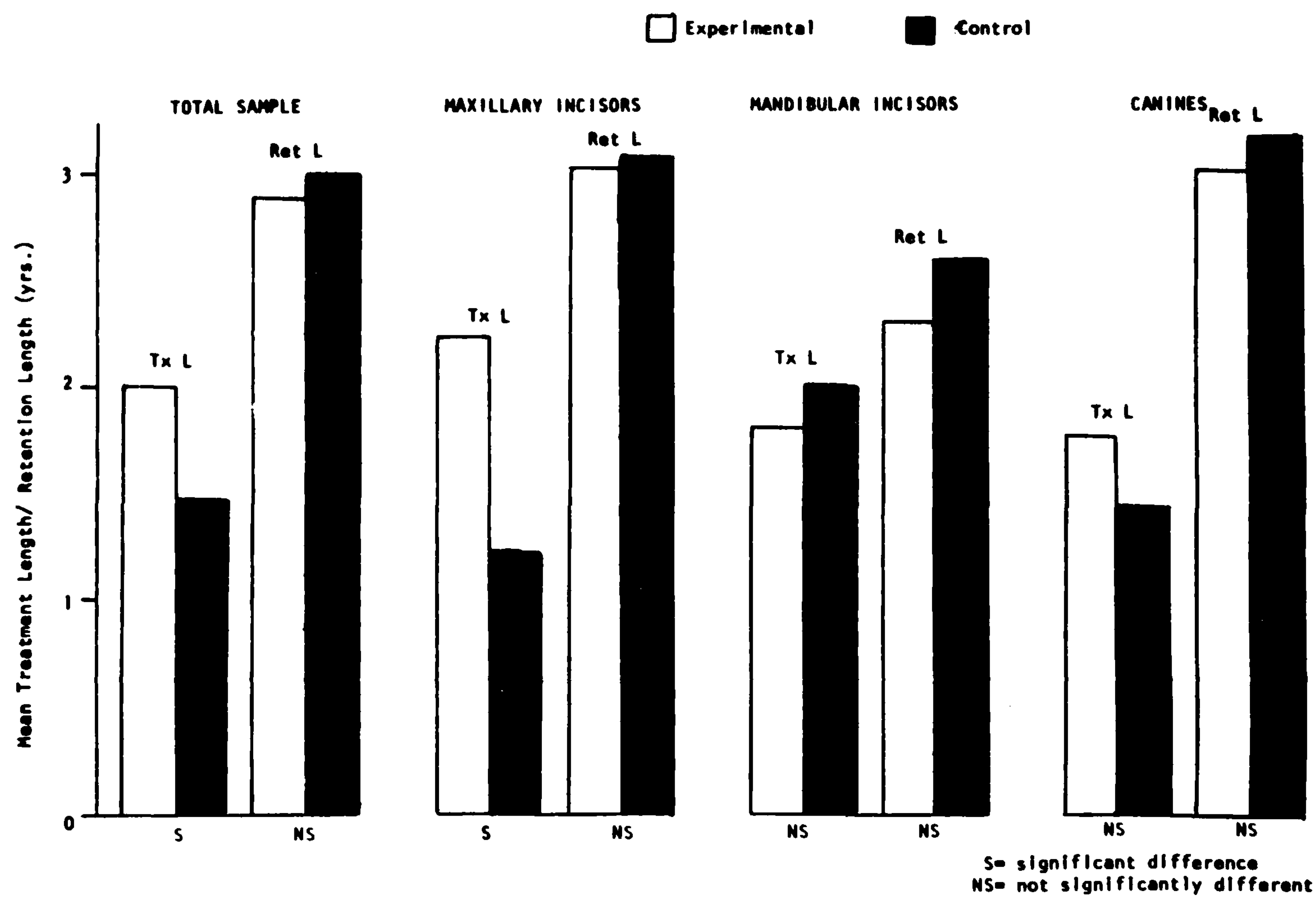
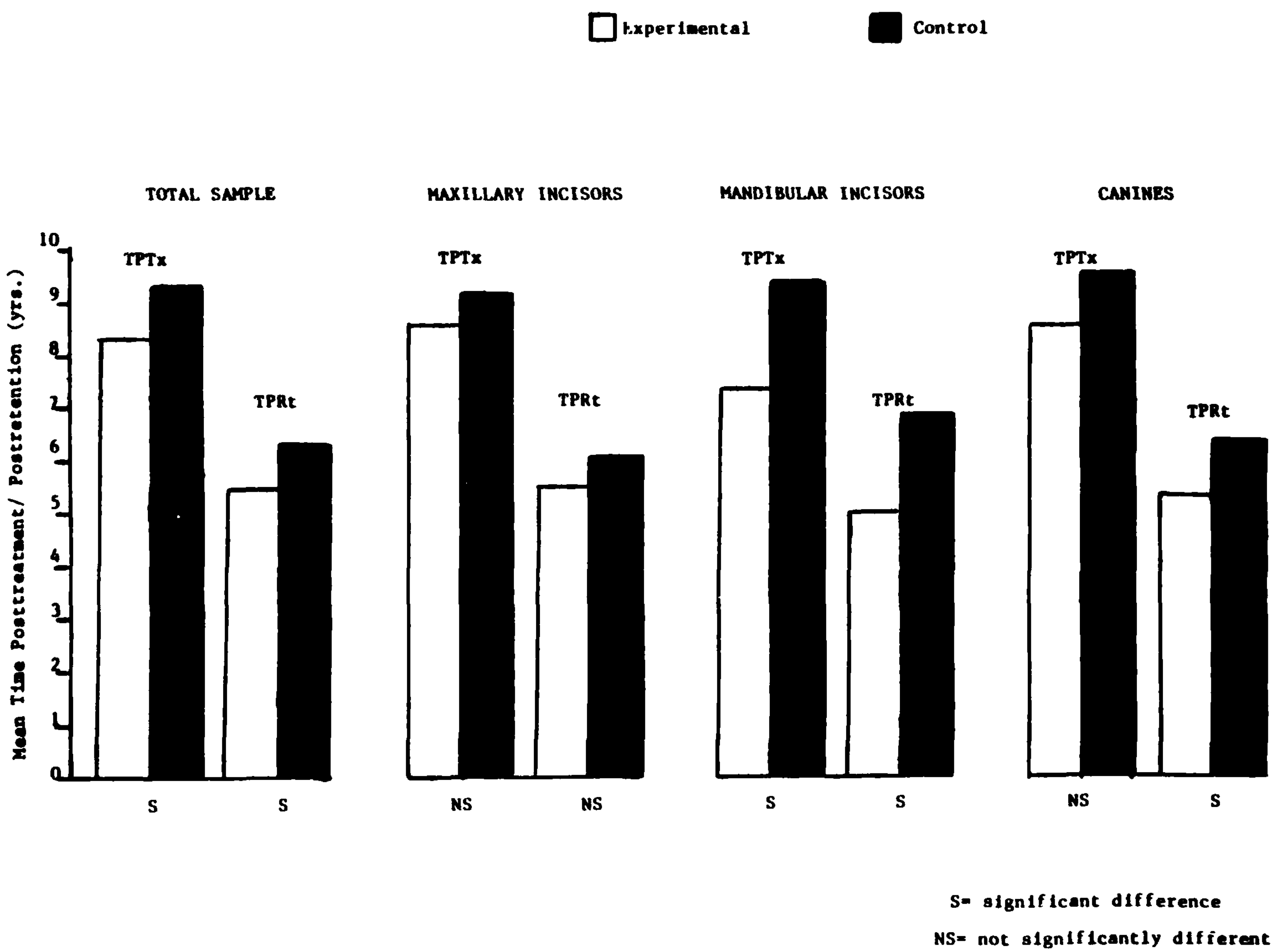

Experimental
Control
TOTAL SAMPLE
MAXILLARY INCISORS
MANDIBULAR INCISORS
CANINES
Tx L
Ret L
Mean Treatment Length/ Retention Length (yrs.)
0
1
2
3
S
NS
S= significant difference
NS= not significantly different

Figure 10: Chart illustrating differences in mean length of time posttreatment and mean length of time postretention between experimental and control groups.



Experimental
Control
TOTAL SAMPLE
MAXILLARY INCISORS
MANDIBULAR INCISORS
CANINES
Mean Time Posttreatment/ Postretention (yrs.)
0
1
2
3
4
5
6
7
8
9
10
TPTx
TPRt
S
NS
S= significant difference
NS= not significantly different

DISCUSSION

Prior to evaluation of the data, it is necessary to examine certain weaknesses inherent in this study. It must be realized that this is a retrospective study and that this examiner had no participation in either the treatment or retention of any individuals involved. Factors which were found to differ between groups, i.e. T_1 age, T_3 age, treatment length, time posttreatment, time postretention were analyzed to assess their influence on the data. Other uncontrolled factors, however, could not be evaluated and may have influenced the results. These factors included:

1) Similar retaining devices were not used in all cases and patient cooperation during retention was unknown.
2) The majority of experimental group participants received circumferential supracrestal fiberotomies; however, in some instances it was unclear what type of fiberotomy had been performed and may have involved only interproximal slicing.
3) The level of participant oral hygiene is unknown.

As this study found no significant differences in stability between tooth categories or arches, the data will be evaluated only as it relates to the total experimental and total control groups.

This study was conducted to ascertain whether fiberotomy was a valid technique in minimizing long term rotational relapse. For the purpose of this study, long term was defined as greater than two years postretention. The mean length of time postretention for the experimental group was 5.37 years ranging from 2.58 to 9.00 years. The control group ranged from 2.50 to 9.17 years postretention with a mean

length of time postretention of 6.34 years.

The evidence obtained would indicate that fiberotomy is beneficial in reducing long term rotational relapse. The mean stability for the fiberotomized group was found to be 77.2 percent while the non-fiberotomized group revealed a mean stability of only 61.0 percent. When this stability difference was subjected to analysis of covariance, the probability that this intergroup difference could have resulted from chance was less than one percent. Expressed in different terms, the surgerized group relapsed on average 22.8 percent compared to 39.0 percent for the non-surgerized group. This represents a regression ratio of control group relapse to experimental group relapse of 1.7 to 1.

This study supports the hypothesis that forces are generated in the gingival fiber apparatus as a tooth is rotated and that these forces are manifested as rotational relapse when the tooth is released from retention. These rotational relapse forces are apparently reduced when the gingival fibers are severed. These forces are seemingly elastic in nature and probably result from stretching of the network of interwoven collagen and oxytalan fibers. Some investigators (Urban, 1931; Harkness, 1968) have suggested that collagen is an "inelastic tissue." However, collagenous gingival fibers are "wavy" in appearance (Thompson, 1959) and highly entwined with oxytalan fibers which have been found to be elastic (Fullmer and Lillie, 1958). Edwards (1968) and Boese (1969) found that oxytalan fibers increased in the gingival tissues of teeth subjected to rotation and suggested that they played an "anchoring" role preventing overstretching of gingival tissues. Although the data presented by these studies is inconclusive, it is not difficult to

perceive that these oxytalan fibers could provide some part of the elastic force necessary for rotational relapse.

Reitan (1959) observed that gingival fiber bundles remained "stretched" after 232 days of retention. Edwards (1968) made the same observation after 5 months of retention. If indeed these stretched gingival fibers contain a latent relapse force, then it becomes obvious that either retention must be maintained beyond 232 days or these stretched fibers must be surgically inactivated. Although no histologic studies have examined the orientation of gingival fibers beyond retention periods of 232 days, this study found no correlation between retention length (> 6 months) and rotational stability for the non-fiberotomized group. This lack of correlation could mean that either: 1) gingival fibers lack the capacity to rearrange in passive orientations during retention , or 2) poor cooperation by some individuals during the initial phase of retention allowed rotational relapse to occur thereby masking the relationship.

Displaced principal fibers of the periodontal ligament have also been implicated as factors in rotational relapse. Unlike gingival fibers, they have been observed to rearrange themselves during retention. Reitan (1959) discovered that principal fibers were fairly well rearranged--fibers oriented perpendicular to the root surface--after only 28 days of retention and completely rearranged after 147 days of retention. Edwards (1968) found that after five months of retention the periodontal ligament fibers were running perpendicular to the root surface. If this principal fiber rearrangement is to be considered a transformation to an unstrained orientation, then it would appear that

retention of rotated teeth is most critical immediately after tooth rotation, becoming less important as principal fibers rearrange. In support of this hypothesis, Boese (1969) found that rotated, gingivectomized monkey teeth relapsed 16.2 percent when retained for 4 weeks compared to only 9.0 percent when retention was extended to 9 weeks. Pinson and Strahan (1973) in a clinical study observed that fiberotomized, rotated teeth retained for less than 16 weeks showed 33.3 percent relapse compared to 22.7 percent relapse when retention periods of 16 to 28 weeks were used. Walsh (1975) found that fiberotomized, rotated teeth relapsed 75 percent when no retention was used, 27 percent when retention was employed for a period of 2 to 12 weeks, but only 9 percent when retention was continued for 13 to 20 weeks.

It would appear from these experimental and histologic studies that principal fibers do play a role in rotational relapse but that this role is diminished with increasing retention periods. This study found a very weak association between treatment length and stability, ($r = .36$, $p \leq .05$), with stability increasing with treatment length, in the fiberotomized sample. Treatment length for this study was measured from the time of archwire placement to the time of debanding. Although all participants were supposedly "in retention" for at least six months subsequent to debanding, in actuality some individuals probably were inadequately retained as the retention appliances used were primarily removable. Assuming that cooperation during retention was poor for some individuals, it becomes apparent that the actual retention period for these patients occurred during the treatment phase in the interval subsequent to tooth rotation but prior to debanding. This relationship

between stability and treatment length could then actually be a measure of the association between retention length and stability for those individuals who were not adequately retained after debanding. This observation, albeit highly speculative, would imply that tooth rotation should be accomplished early on in treatment, thereby maximizing principal fiber reorientation at the time of debanding and minimizing their potential to induce relapse.

If gingival fibers are inactivated by surgical intervention and teeth retained for periods necessary for principal fiber rearrangement, one might expect that these teeth would remain perfectly stable. This appears, however, not to be the case. All studies have observed some degree of relapse of surgerized teeth regardless of retention length. Possible explanations for this phenomenon could include: 1) inadequate transsection of gingival fibers, 2) latent elastic forces within stretched principal fibers which become encased in alveolar bone during retention but are subsequently exposed as this alveolar bone is remodeled over time, 3) muscular and occlusal forces, or 4) reattachment of severed gingival fibers prior to the release of strain developed during tooth rotation. This study observed a mean surgical group relapse of 22.8 percent which is higher than most other observers have encountered. Mean relapse percent, however, was significantly less for the surgerized group than the non-surgerized group and would indicate that fiberotomy is a valid technique for minimizing rotational relapse although one must not expect to achieve perfect stability in every case.

This study suggests that fiberotomy is an aid to enhancing rotational stability probably by inactivating elastic forces within the

gingival fiber apparatus. One must not conclude, however, that stretched gingival or principal fibers are the sole causes of rotational relapse. After discontinuing retention, 19 percent of the fiberotomized teeth in this study rotated away from their original pretreatment positions. Eleven percent of the non-fiberotomized teeth rotated away from their original positions. This phenomenon of reverse relapse cannot be explained by relaxation of fibers. Clearly other forces must be necessary to cause this unusual relapse pattern.

Contrary to the findings of Swanson, Riedel, and D'Anna (1975), this study found no significant difference in percent relapse between different types of teeth, e.g. incisors vs. canines. These subgroups were small, however, and a larger sample size may have revealed a significant difference in percent relapse between different tooth categories. Also contrary to Swanson, et al., and Wiser (1961), no significant association was found to exist between the amount of treatment rotation and percent relapse of rotation for either the fiberotomized or non-fiberotomized groups. This study is in agreement with Boese (1968) who also observed that relapse was not related to treatment rotation. Several factors may explain why this relationship was not found to exist for the non-fiberotomized group in this study:

1) Oral hygiene varies between patients and may have an influence on relapse. Edwards (1971) observed that individuals with "the poorest hygiene and most frequent gingival inflammation appeared to have the least relapse problems between the orthodontically approximated teeth." He speculated that inflammation might actually destroy the disoriented gingival fibers resulting

in the formation of new unstrained fibers.

2) It can be hypothesized that the degree of principal fiber rearrangement has an influence on relapse in non-surgerized individuals. If we assume that reoriented principal fibers resist rotational relapse induced by gingival fiber contraction, the less complete the rearrangement of principal fibers when retention is terminated, the greater will be the relapse.

If the variables of poor oral hygiene and inadequate retention had been controlled in this study, it is possible that a relationship between treatment rotation and relapse may have been observed.

SUMMARY AND CONCLUSIONS

This study was undertaken to assess the long term clinical efficacy of fiberotomy as it relates to rotational relapse. Forty-eight orthodontic patients who had been previously treated either in the UW Orthodontic Clinic or in the private practice of Dr. Richard Riedel provided 91 non-fiberotomized, orthodontically rotated teeth and 73 fiberotomized, orthodontically rotated teeth from which data was collected. As this was a retrospective study, control over patient treatment and retention was not possible. Treatment in all cases was accomplished by edgewise appliances. Seventy-three teeth received fiberotomies either immediately prior to debanding or shortly subsequent to debanding. The fiberotomy technique used was usually circumferential supracrestal fiberotomy; however, in a few cases it was uncertain what technique had been used and perhaps only interproximal slices were performed. All teeth were retained for a period of at least six months following treatment but the retention appliances utilized were predominantly removable and hence the quality of retention was surely variable. Assessment of rotational relapse was made after a minimum of two years postretention.

Changes in rotational tooth position were measured from photocopies made at three time periods: pretreatment, posttreatment, and postretention.

Mean stability, a measure of percentage of treatment rotation maintained at the postretention period, was found to be 77.2 percent for the surgerized group compared to 61.0 percent for the non-surgerized group. Expressed as percentage relapse, the fiberotomized teeth revealed a mean relapse of 22.8 percent compared to 39.0 percent for the non-fiberotomized

teeth. This represents a control group to experimental group regression ratio of 1.7 to 1. The difference in stability between groups was statistically significant. The probability that this difference could have occurred due to chance was less than one percent.

Based on the findings of this study, the following conclusions were made:

1) Fiberotomy will reduce the potential for rotational relapse possibly by removing the influence of displaced gingival fibers.
2) There does not appear to be a difference in relapse potential between arches or tooth categories.
3) There does not appear to be a relationship between amount of treatment rotation and percent relapse.

Future histologic and clinical studies are recommended to elucidate more clearly:

1) whether gingival fibers remain stretched for longer retention periods than 232 days;
2) what influence gingivitis has on gingival fiber orientation;
3) how long it takes for gingival fibers to reattach subsequent to fiberotomy and whether or not they are unstrained at the time of reattachment.

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